Rec'd PCT/PTO 14 JAN 2005

PCT/CN03/00540

证 明

CERTIFICATE

REC'D 10 SEP 2003
WIPO PCT

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国 际 申 请 号: PCT/CN02/00503

INTERNATIONAL APPLICATION NUMBER

国 际 申 请 日: 17 JUL 2002（17.07.02）

INTERNATILNAL FILING DATE

发 明 名 称： **MULTIPLE SERVICE RING WITH CAPABILITIES OF TRANSMITTING AND SWITCHING DATA VIDEO VOICE**

TITLE OF INVENTION

申 请 人: **WUHAN FIBERHOME NETWORKS CO.,LTD.**

APPLICANT

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

中华人民共和国国家知识产权局局长

COMMISSIONER OF THE STATE INTELLECTUAL PROPERTY OFFECE OF THE PEOPLE'S REPUBLIC OF CHINA

王景川

二零零三年八月二十五日

AUGUST 25, 2003

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PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No. T/CN 02/ 0 0 5 0 3

International Filing Date 17 JUL 2002 (17. 07. 02)

Name of receiving Office and "PCT International Application" RO/CN 中华人民共和国国家知识产权局 PCT International Application

Applicant's or agent's file reference *(if desired) (12 characters maximum)* **I02CN025/HL**

Box No. I TITLE OF INVENTION

MULTIPLE SERVICE RING WITH CAPABILITIES OF TRANSMITTING AND SWITCHING DATA, VIDEO AND VOICE

Box No. II APPLICANT ☐ This person is also inventor

Name and address: *(Family name followed by given name; for a legal entity, full official esignation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

WUHAN FIBERHOME NETWORKS CO., LTD.

88 Youkeyuan Lu, Hongshan District, Wuhan City, Hubei Province, 430074
China

Telephone No.

Facsimile No.

Teleprinter No.

Applicant's registration No. with the Office

State *(that is, country)* of nationality: CN

State *(that is, country)* of residence: CN

This person is applicant for the purposes of: ☐ all designated States ☑ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

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88 Youkeyuan Lu, Hongshan District, Wuhan City, Hubei Province, 430074
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This person is:

☐ applicant only

☑ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: CN

State *(that is, country)* of residence: CN

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☑ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☑ agent ☐ common representative

LIU, SHEN & ASSOCIATES

A0601, HUIBIN BUILDING, NO.8 BEICHEN DONG STREET

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86-10-64993490

Facsimile No. 86-10-64993491
86-10-64993498

Teleprinter No.

Agent's registration No. with the Office

☐ Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box [illegible] DESIGNATION [illegible]ATES *Mark the applicable check-boxes below; at least one must be marked.*

The following designations are hereby made under Rule 4.9(a):

Regional Patent

☑ **AP** **ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, MZ Mozambique, SD Sudan, SL Sierra Leone, SZ Swaziland, TZ United Republic of Tanzania, UG Uganda, ZM Zambia, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT (if other kind of protection or treatment desired, specify on dotted line)..................................

☑ **EA** **Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

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....

National Patent *(if other kind of protection or treatment desired, specify on dotted line):*

☑ AE United Arab Emirates
☑ AG Antigua and Barbuda
☑ AL Albania
☑ AM Armenia.......
☑ AT Austria.......and Utility Model
☑ AU Australia......
☑ AZ Azerbaijan
☑ BA Bosnia and Herzegovina....
☑ BB Barbados
☑ BG Bulgaria........
☑ BR Brazil ....
☑ BY Belarus........
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☑ CA Canada........
☑ CH AND LI Switzerland and Liechtenstein
☑ CN China ....
☑ CO Colombia
☑ CR Costa Rica......
☑ CU Cuba...........
☑ CZ Czech Republic...and Utility Model
☑ DE Germany ....and Utility Model
☑ DK Denmark ....and Utility Model
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☑ DZ Algeria.........
☑ EC Ecuador.........
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☑ ES Spain............
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☑ GB United Kingdom
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☑ LC Saint Lucia.......
☑ LK Sri Lanka........
☑ LR Liberia..........
☑ LS Lesotho..........
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☑ MG Madagascar......
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☑ MN Mongolia
☑ MW Malawi..........
☑ MX Mexico..........
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☑ NZ New Zealand......
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☑ SG Singapore
☑ SI Slovenia.........
☑ SK Slovakia.........and Utility Model
☑ SL Sierra Leone.....
☑ TJ Tajikistan........
☑ TM Turkmenistan.....
☑ TN Tunisia
☑ TR Turkey ....
☑ TT Trinidad and Tobago...
☑ TZ United Republic of Tanzania ...
☑ UA Ukraine.........
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Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.

(Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)

Box No. VI PRIORITY CLAIM

The priority of the following earlier application(s) is hereby claimed:

Filing date of earlier application *(day/month/year)*	Number of earlier application	Where earlier application is: national application: country or Member of WTO	regional application:* regional Office	international application: receiving Office
item(1)				
item(2)				
item(3)				
item(4)				
item(5)				

☐ Further priority claims are indicated in the Supplemental Box.

The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office)* identified above as:

☐ all items ☐ item (1) ☐ item (2) ☐ item (3) ☐ item (4) ☐ item (5) ☐ other, see Supplemental Box

* *Where the earlier application is an ARIPO application, indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed (Rule 4.10(b)(ii)):* ....

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):*

ISA/ CN

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*

Date (day/month/year) Number Country (or regional Office)

Box No. VIII DECLARATIONS

The following declarations are contained in Boxes Nos. VIII (i) to (v) *(mark the applicable check-boxes below and indicate in the right column the number of each type of declaration):*

Number of declarations

☐ Box No. VIII (i) Declaration as to the identity of the inventor :

☐ Box No. VIII (ii) Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent :

☐ Box No. VIII (iii) Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application :

☐ Box No. VIII (iv) Declaration of inventorship (only for the purposes of the designation of the United States of America) :

☐ Box No. VIII (v) Declaration as to non-prejudicial disclosures or exceptions to lack of novelty :

PCT/CN 02/ 0 0 5 0 3

Box [redacted]HECK LIST; LA[redacted]GE OF FILING

This international application contains:
(a) the following number of **sheets in paper form:**

request (including declaration sheets)	:	4
description (excluding sequence listing part)	:	92
claims	:	8
abstract	:	1
drawings	:	16
Sub-total number of sheets	:	121
sequence listing part of description *(actual number of sheets if filed in paper form, whether or not also filed in computer readable form; see (b) below)*	:	
Total number of sheets	:	121

(b) sequence listing part of description filed in **computer readable form**

(i) ☐ only (under Section 801(a)(i))
(ii) ☐ in addition to being filed in paper form (under Section 801(a)(ii))

Type and number of carriers (diskette, CD-ROM, CD-R or other) on which the sequence listing part is contained *(additional copies to be indicated under item 9(ii), in right column):*

. . . .

This international application is accompanied by the following item(s)*(mark the applicable check-boxes below and indicate in right column the number of each item):*

		Number of items
1. ☑ fee calculation sheet	:	1
2. ☐ original separate power of attorney	:	
3. ☐ original general power of attorney	:	
4. ☐ copy of general power of attorney; reference number, if any:	:	
5. ☐ statement explaining lack of signature	:	
6. ☐ priority document(s) identified in Box No. VI as item(s):	:	
7. ☐ translation of international application into (language):	:	
8. ☐ separate indications concerning deposited microorganism or other biological material	:	
9. ☐ sequence listing in computer readable form (indicate also type and number of carriers (diskette, CD-ROM, CD-R or other))	:	
(i) ☐ copy submitted for the purposes of international search under Rule 13ter only (and not as part of the international application)	:	
(ii) ☐ (only where check-box (b)(i) or (b)(ii) is marked in left column) additional copies including, where applicable, the copy for the purposes of international search under Rule 13ter	:	
(iii) ☐ together with relevant statement as to the identity of the copy or copies with the sequence listing part mentioned in left column	:	
10. ☐ other (specify):	:	

Figure of the drawings which should accompany the abstract: FIG. 1

Language of filing of the international application: English

Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

LIU, SHEN & ASSOCIATES
北京市柳沈律师事务所申请专用

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1. Date of actual receipt of the purported international application:	17 JUL 2002 (1 7. 0 7. 0 2)
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2)	
2. Drawings: ☐ received: ☐ not received:	
5. International Searching Authority (if two or more are competent):	ISA/
6. ☐ Transmittal of search copy delayed until search fee is paid	

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[redacted] PCT [redacted]
F[redacted]ALCULATION SHEET
Annex to the Request

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International Application No.	PCT/CN 02/ 00503
17 JUL 2002 (17.07.02)	
Date stamp of the receiving Office	

Applicant's or agent's file reference: I02CN025/HL

Applicant: WUHAN FIBERHOME NETWORKS CO., LTD.; YU, Shaohua

CALCULATION OF PRESCRIBED FEES

			Receiving Office
1. TRANSMITTAL FEE	CNY 500.00	T	CNY500.-
2. SEARCH FEE	CNY 1,500.00	S	CNY1500.-

International search to be carried out by CN

(If two or more International Searching Authorities are competent to carry out the international search, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic Fee

Where item (b) of Box No. IX applies, enter **Sub-total number of sheets**
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b1	first 30 sheets	CHF 650.00	b1	CHF650.-
b2	91 (number of sheets in excess of 30) X CHF 15 (fee per sheet) =	CHF 1,365.00	b2	CHF1365.-

b3 additional component (only if sequence listing part of description is filed in computer readable form under Section 801(a)(i), or both in that form and on paper, under Section 801(a)(ii)):

400 X 0 (fee per sheet) = CHF 0.00 b3

Add amounts entered at b1, b2 and b3 and enter total at B	CHF 2,015.00	B	CHF2015.-

Designation Fees

The international application contains 93 designations.

5 (number of designation fees payable (maximum 5)) X CHF 140 (amount of designation fee) =	CHF 700.00	D	CHF700.-
Add amounts entered at B and D and enter total at I	CHF 2,715.00	I	CHF2715.-

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the sum of the amounts entered at B and D.)

4. FEE FOR PRIORITY DOCUMENT *(if applicable)*	CNY 0.00	P	
5. TOTAL FEES PAYABLE Add amounts entered at T, S, I and P, and enter total in the TOTAL box	CNY 2,000.00 CHF 2,715.00 TOTAL		CNY2000.- CHF2715.-

☐ The Designation fees are not paid at this time.

MODE OF PAYMENT

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Date: 17 July 2002

Name:

Signature:

LIU, SHEN & ASSOCIATES
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Form PCT/RO/101 (Annex) (January 2002; reprint July 2002)

See Notes to the fee calculation sheet

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PCT/CN02/00503

MULTIPLE SERVICE RING WITH CAPABILITIES OF TRANSMITTING AND SWITCHING DATA, VIDEO AND VOICE

Field of the invention

The present invention relates to a multiple service ring with capabilities of transmitting and switching data, video and voice used in metro area network, so called Link Encapsulation Method (LEP) used to Multiple Services Ring (MSR), which is provided for default use on a bi-directional symmetric counter-rotating two fibre optical rings, and can also be changed to the use of single fibre ring, link-type and broadcast topology, and specifically, relates to a data transmission apparatus used in a multiple service ring including at least two nodes coupled to at least one aggregate pipe and at least one tributary, the multiple service ring thus formed and the method therefor.

Background art

The present invention is made on the basis of a PCT international application No. PCT/CN02/00066 of the same applicant as the present application filed on February 6, 2002 describing a resilient multiple service ring, therefore all the contents and disclosure of PCT/CN02/00066 are incorporated in the present application as a part of the present application.

The expansion of business and personal use of data network services are driving the need to deploy data services infrastructure facilities in parts of the world that have yet to be deployed. The development of data network and related application needs to provide the following capabilities:

(1) The protocol encapsulation and transport of Ethernet, Gigabit Ethernet, G.707 SDH circuit -- Transport of TU-11, TU-12 or TU-2, G.702 PDH circuit -- Synchronous and asynchronous circuit transport, Video signal, Voiceband signal, Digital channel supported by 64 kbit/s-based ISDN etc over a bi-directional

symmetric counter-rotating two fibre optical rings (in the most case), a single fibre ring, a link-type and broadcast topology of fibres.

(2).Both service (or tributary) based protection and aggregate based protection within 50ms.

(3) Service (or tributary) based protection of 1+1, 1:1, and 1:N models.

(4) Both service (or tributary) based multicast and station-based multicast.

(5) Bandwidth limitation of service (or tributary) based.

(6) Tributary bundle with the same service type.

(7) Line-speed filtering of tributary based.

(8) Mirroring of tributary.

(9) Frame based transparent PPPoE and PPPoA transport from access to backbone along a MSR ring, in order to simplify accounting mechanism (e.g. Radius), reduce maintenance work, and improve latency variation (compared to Layer 2 and Layer 3 switch) in Metro Area Network.

The prior art systems do have the complexity of multiple layers of equipment and support system, and can not provide the above functions.

Summary of the invention

The object of the present invention is to provide a Data node running LEP and the ring system formed by the LEP nodes, which can achieve the above functions in a simple manner and does not have the complexity of multiple layers of equipment and support systems.

To achieve the above objects, the present invention provides a data transmission apparatus used in a multiple service ring including at least two nodes coupled to at least one aggregate pipe and at least one tributary, said apparatus comprising: a TDM tributary RX framer coupled to a TDM tributary for deframing data frames received from said TDM tributary and extracting a destination node address, each of said data frames containing a plurality of channels in TDM manner; a TDM identifier setting-

up means for setting-up a TDM identifier indicating said data to be transmitted are TDM data; a TDM channel identifier setting-up means for setting-up a channel identifier indicating a specific TDM channel No. of the data to be transmitted; and a TX framer for encapsulating the destination node address, the TDM identifier, the TDM channel identifier, and said TDM data to be transmitted into frames of the multiple service ring and transmitting the same along the aggregate pipe to a downstream neighbor node in the ring. The data transmission apparatus further comprising: a RX framer for deframing data frames including a destination node address, at least one service type identifier, and actual data received from a aggregate pipe; a service type determining means for determining the service type of received data based on said service type identifier, if the value of said service type identifier indicates that the received actual data are TDM data, determining the TDM channel No. from another TDM channel identifier preset at the transmitting node;
a TDM data extracting means for extracting the TDM data from the channel designated by said TDM channel No.; and a TDM tributary TX framer for encapsulating said extracted TDM data into data frames to be transmitted to said TDM tributary.

The present invention further provides a resilient multiple service ring system comprising a plurality of nodes, each node including a data transmission apparatus defined as above, wherein each of said nodes is assigned a node address(NA), and data incoming to a node contains a destination node address, and said destination node address is XOR'ed with the NA of the local node to check for match or mismatch. And an external timing source is provided to one of the nodes in the ring, and the other nodes make reference to the timing signaling from said one node for synchronization.

The present invention further provides a data transmission method used in a multiple service ring including at least two nodes coupled to at least one aggregate pipe and at least one tributary, comprising the steps of: deframing data frames received from a

TDM tributary and extracting a destination node address, each of said data frames containing a plurality of channels in TDM manner; setting-up a TDM identifier indicating said data to be transmitted are TDM data; setting-up a channel identifier indicating a specific TDM channel No. of the data to be transmitted; and encapsulating the destination node address, the TDM identifier, the TDM channel identifier, and said TDM data to be transmitted into frames of the multiple service ring and transmitting the same along the aggregate pipe to a downstream neighbor node in the ring. Said method further comprising the steps of: deframing data frames including a destination node address, at least one service type identifier, and actual data received from a aggregate pipe; determining the service type of received data based on said service type identifier, if the value of said service type identifier indicates that the received actual data are TDM data, determining the TDM channel No. from another TDM channel identifier preset at the transmitting node; extracting the TDM data from the channel designated by said TDM channel No.; and encapsulating said extracted TDM data into data frames to be transmitted to said TDM tributary.

According to the present invention, the simplicity of LEP used to MSR is achieved by integrating the functionality of multiple levels of system (e.g., router, data switch and transport system). This produces a new kind of data system that incorporates some of the functions of routers, bridges, data switches, and transport systems. This also provides a new economic model for deploying and supporting data services. Continued compatibility with all existing requirements and standards from ITU-T and other organizations is required. MSR-LEP is designated to achieve all of these.

Brief description of the drawings

The present invention is illustrated by way of example and not limited by the figures of the accompanying drawings, in which like references indicate similar elements and in which:

Fig. 1 illustrates the the Topology of Multiple Services Ring according to the present invention;

Fig. 2 illustrates Tx and Rx Function Diagram of MSR Data Node;

Fig. 3 is Protocol Stack of Ethernet over SDH/SONET using MSR-LEP in SDH/SONET based Aggregate Pipe;

Fig. 4 Protocol Stack of IP over SDH/SONET using MSR-LEP in SDH/SONET based Aggregate Pipe, it will be used to network management, control signalling and Layer 3 forwarding packet;

Fig. 5 illustrates Protocol Stack of Ethernet over GE or 10GE in GE or 10GE based Aggregate Pipe;

Fig. 6 is Protocol Stack of IP over Ethernet in GE and 10GE based Aggregate Pipe, it will be used to network management, control signalling and Layer 3 forwarding packet;

Fig. 7 illustrates a Generic Protocol Stack of MSR;

Fig. 8 is Generic Frame Format of MSR;

Fig. 9 illustrates Generic Format of CS & NM Frames;

Fig. 10 illustrates Expressions of TN ID and TCCR ID.

Fig. 11A and B shows the diagrams of the scrambling and descrambling at the transmitter and receiver.

Fig. 12 illustrates The TDM Service Channel along MSR;

Fig. 13 illustrates TDM SERVICE CHANNEL OVER OCTET ORIENTED MSR-LEP;

Fig. 14 illustrates THE TDM SERVICE CHANNEL OVER BIT ORIENTED MSR-LEP;

Fig. 15 is The Single Fibre Ring of MSR;

Fig. 16 is A MSR Topology, Link-type with Adding and Dropping Tributary Services.

Fig. 17 is A MSR Topology, Broadcast Connection to DVB Application.

Fig. 18 is A MSR Topology, Pseudo-mesh Connection according to the invention..

Fig. 19 is a hardware architecture example of MSR

Fig. 20 is a layout of MSR shelf of the invention.

Detailed description of the preferred embodiment

1 Scope

This patent presents Link Encapsulation Protocol (LEP) and method Used to Multiple Services Ring (MSR). LEP is provided for default use on a bi-directional symmetric counter-rotating two fibre optical rings, and can also be changed to the use of single fibre ring, link-type and broadcast topology. Primary optical transport mechanism is defined to leverage the low cost Wide Area Interface Sublayer (WIS) of 10Gigabit Ethernet (IEEEP802.3ae). SDH/SONET physical transport is also supported. The service tributary interfaces of MSR are defined to support Ethernet and TDM Circuit Emulation (including the emulation of G.707 SDH circuit -- Transport of TU-11, TU-12 or TU-2, G.702 PDH circuit -- Synchronous and asynchronous circuit transport, Video signal, Voiceband signal, Digital channel supported by 64 kbit/s-based ISDN) and other MSR Tributary with a lower rate of aggregate pipe. LEP supports node based protection, tributary based 1+1, 1:1 and 1:N protection, and tributary based multicast, tributary bandwidth Limitation, tributary bundle, tributary Line-Speed Filtering, tributary Mirroring, and is also defined to support forwarding of the MSR data link frame (also being a tributary) similar to functionality found in a more complex routing data system. MSR is targeted for market areas of the world having a low-cost solution, provisioning and support requirements. Aggregate pipe can be any kind of STM-1/OC-3 (VC4), STM-4/OC-12 (VC4-4c), STM-16/OC-48 (VC4-16c), STM-64/OC-192 (VC4-64c), Gigabit Ethernet and 10Gigabit Ethernet.

This patent does not present the method of mapping LEP method to SDH/SONET or Ethernet. No change is made for all Ethernet-based protocols (including IEEE 802.3 Ethernet), all SDH/SONET standards, ATM standards, POS standards and ETSI DVB specifications.

2 References

The following ITU-T Recommendations, and other references contain provisions which, through reference in this text, constitute provisions of this Patent. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision: all users of this Patent are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of currently valid ITU-T Recommendations is regularly published.

2.1 ITU-T Recommendations

[1] ITU-T Recommendation X.85/Y.1321, *IP over SDH using LAPS.*

[2] ITU-T Recommendation X.86/Y.1323, *Ethernet over LAPS.*

[3] ITU-T Recommendation X.211 (1995) | ISO/IEC 10022 (1996), *Information technology - Open Systems Interconnection - Physical service definition.*

[4] ITU-T Recommendation X.212 (1995) | ISO/IEC 8886 (1996), *Information technology - Open Systems Interconnection - Data link service definition.*

[5] ITU-T Recommendation G.707 (1996), *Network node interface for the synchronous digital hierarchy (SDH).*

[6] ITU-T Recommendation G.708 (1999), *Sub STM-0 network node interface for the synchronous digital hierarchy (SDH).*

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[12] ITU-T Recommendation I.361 (1999), B-ISDN ATM Layer specification.

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2.2 IEEE Specifications

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2.3 ETSI

[15] EN 300 429: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems".

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[17] EN 500 83: "Cabled distribution systems for television, sound and interactive multimedia signals; Part 9: Interfaces for CATV/SMATV headends and similar professional equipment for DVB/MPEG2 transport streams" (CENELEC)".

[18] ETR 290: "ETR 290: "Digital Video Broadcasting (DVB); Measurement guidelines for DVB systems".

2.4 ANSI

[19] ANSI T1.105 - 1991, *"Digital Hierarchy – Optical Interface Rates and Formats Specification", American National Standard for Telecommunications, 1991.*

2.5 IETF

[20] RFC 2615, *"PPP over SONET/SDH"*, A. Malis, *Internet Engineering Task Force, 1999.*

[21] RFC 2615, " PPP in HDLC-like Framing ", W. Simpson,, *Internet Engineering Task Force, 1994.*

3 Definitions

For the purposes of this patent, the following definitions apply:

3.1 Aggregate Pipe: two symmetric counter fibre channels used to connect adjacent MSR data nodes along the First and Second Working Ring. Aggregate pipe is a channel of STM-1/OC-3 (VC4), STM-4/OC-12 (VC4-4c), STM-16/OC-48 (VC4-16c), STM-64/OC-192 (VC4-64c), or virtual concatenation of a set of VC4 or VC3, Gigabit Ethernet or10Gigabit Ethernet. It is recommended that the same bandwidth of Aggregate Pipe in different span along the same ring is required. When SDH/SONET is applied to Aggregate Pipe, the overhead and other specifications of regeneration, multiplex section and high-order VC specified in ITU-T G.707 is used.

3.2 Control Signalling Frame: a Frame used to Topology Discovery, Layer 2 Protection Switching of Manual Switch or Forced Switch etc in a node.

3.3 CT_Request Frame: a frame used to send a configuration table request from Node A to Node B.

3.4 CT_Response Frame: a frame used to send a configuration table response from Node B to Node A.

3.5 Configuration Table (CT): a mapping table reflecting the actual and using value of TT and TN in a node and TCCR between nodes on the MSR ring during engineering operation.

3.6 Configuration Table Inquiry (CTI): a function to get CT from a node. CT_Request frame with a CTI parameter reflecting changing part of TCCR of a node on MSR ring is sent to other nodes (called one of them Node B) by unicast/multicast/broadcast mode from a node (called Node A, e.g. Central station in the most case) by network management interface during normal engineering operation

period. All nodes received CT_Request frame with a CTI parameter will give a point-to-point response by CT_Response frame with a CTI parameter reflecting actual configuration table of the local node on MSR ring to Node A.

3.7 Configuration Updating Table (CUT): a mapping table reflecting the available value modification of TT and TN in a node and TCCR between nodes on the MSR ring during engineering operation. The CUT is applied during MSR engineering operation. The incorrect ICT will lead to fault of Tributary on MSR ring. CT_Request frame with an CUT parameter reflecting changed part of TCCR of all node on MSR ring is sent to other nodes by broadcast mode from a node (e.g. Central station in the most case) by network management interface during normal engineering operation period. All nodes received CT_Request frame will build corresponding mapping relations of TCCR in the local node and give a point-to-point response by CT_Response frame to that node sending CT_Request frame. After getting CT-Response frame, that node sourcing CT_Request frame issues a CT_Confirm frame to that remote node sending CT_Response frame.

3.8 First Working Ring (FWR): an outer or inner ring on the MSR. It can be defined as one of two symmetric counter-rotating rings. Default configuration of First Working Ring is set to outer ring. It is programmable and is also set to the inner ring when the Second Working Ring is set to the outer ring. In the case of SWR fibre facility or node failure, First Working Ring can be seen as bypass channel of Second Working Ring.

3.9 Forced Switch: operator does by network management or software debug facility, perform L2PS on the target span. Operational priority is higher than Manual Switching.

3.10 FWR-Fibre-Cut: a parameter of L2PS_Request Frame, used to stand for status indication of single fibre cut on FWR.

3.11 Initial Configuration Table (ICT): a mapping table reflecting the initial and available value of TT and TN in a node and TCCR between nodes on the MSR ring during engineering installation. The ICT must be pre-installed by (NVROM or FLASH RAM) before MSR engineering operation. The incorrect ICT will lead to

fault of Tributary services on MSR ring. CT_Request frame with an ICT parameter reflecting initial TCCR of all nodes on MSR ring is sent to other nodes by broadcast mode from a node (e.g. Central station in the most case) by network management interface during initial engineering operation period. All nodes received CT_Request frame will build corresponding mapping relations of TCCR in the local node and give a point-to-point response by CT_Response frame to that node sending CT_Request frame. After getting CT-Response frame, that node sourcing CT_Request frame issues a CT_Confirm frame to that remote node sending CT_Response frame.

3.12 **L2 Protection Switching (L2PS)**: a powerful self-healing feature that allows to recovery from fibre facility or node failure within 50ms. Analogous to the K1/K2 protocol mechanism that SONET/SDH ring does. L2PS entity in a node detects link status. If neither flag nor frame is received by a node in Rx direction within 20ms (its value is programmable) in the FWR or SWR of aggregate pipe, or if fibre facility or a node is failure (e.g. PSD or PSF), two nodes on failure span will enter L2PS State.

3.13 **Layer 3 Forwarding Packet**: a packet used to forward data packet in a node. This packet is different from those packets of reaching all Tributary in a node, is also different from network management frames and control signalling frames. Logically, a node can be treated as a router of performing Layer 3 forwarding when a Layer 3 forwarding Packet is forwarded according to routing table and routing protocols of Ipv4/6 in a node from the node to other node along the MSR

3.14 **L2PS_ Request Frame**: a frame used to send a Manual Switch or Forced Switch request from Node A to two adjacent nodes (Node B and C) of targeted span or to two adjacent nodes (Node B and C) of failure node.

3.15 **L2PS State**: If a node receives neither flag nor frame within 20ms (its value is programmable) in the FWR or SWR of aggregate pipe, or if fibre facility or a node is failure (e.g. PSD or PSF), two nodes on failure span will enter L2PS State.

When a node enters L2PS State, forwarding means that received frame from a side of node will be forwarded to same side of this node (that is, received frame from westward on FWR will be forwarded to westward on SWR.). It does not look like a

node in Normal State, forwarding means that received frame from westward on FWR will be forwarded to eastward on FWR.

3.16. **Manual Switch**: operator does by network management or software debugging facility, perform L2PS on the target span.

3.17 **Multiple Services Ring (MSR)**: a bi-directional symmetric counter-rotating fibre rings consisted of at least two nodes (refer to Figure 1), each node could add and drop one or more independent Tributary. MSR supports multiple nodes transmit simultaneously and traffic engineering. A node can be inserted or removed online from the ring while other nodes and services in the working channel will be operated normally without packet loss and service loss.

3.18 **MSR Broadcast**: a frame transmitted from a node can be sent to all other nodes along FWR or SWR by using MSR-LEP.

3.19 **MSR Filter Unit**: a filtering and checking facility for frame NA and TTL. All frames reaching to the MSR filter Unit will be sent first to a buffer in the Node. The MSR data node will check frame TTL and NA and perform XOR function with local NA. This frame will be taken away if TTL is zero. If its NA is match, those frames reaching destination will not be sent to neighbor (except for multicast and broadcast frames) along the same ring. Otherwise, those mismatched frame will go to neighbor directly by schedule unit without any processing after decrementing TTL field. This is MSR filtering function.

3.20 **MSR Multicast**: a frame transmitted from a node can be sent to several different nodes along First or Second Working Ring by using MSR-LEP.

3.21 **MSR Data Node**: a system equipment that has an eastward Rx, eastward Tx, westward Rx and westward Tx Aggregate Pipe connections, and one or more adding and dropping independent Tributaries. It also has functions of receiving, transmitting and forwarding of network management frame, control signalling and data frame in a Node.

3.22 **MSR-LEP**: a data link protocol between MAC/TCE (or PPP/Ipv4/Ipv6) frame (or packet) and the physical layer of aggregate pipe, used to communication between different nodes on the Multiple Services Ring. The MSR-LEP does operate by

sending both data frame and the associated network management/control frames in FWR, sending both data frame and the associated network management /control frames in SWR also. When SDH/SONET is applied to Aggregate Pipe, MSR-LEP is octet oriented. For GE and 10GE, MSR-LEP is bit oriented.

3.23 **MSR-LEP Rx Processor**: a set of functions used to MSR-LEP processing in Rx direction. It includes Rx Filter Unit, discrimination of multicast/broadcast and TT/TN value and other associated MSR-LEP processing.

3.24 **MSR-LEP Tx Processor**: a set of functions used to MSR-LEP processing in Tx direction. It includes Tx Schedule Unit, functions of determination of NA, TTL, TT, TN, FCS, multicast/broadcast according to types and ports configuration of Tributary, a route of Layer 3 forwarding packet, requirement of control signalling or requirement of network management. The other associated MSR-LEP processing is also covered.

3.25 **MSR Schedule Unit**: a control function for transmitted frame in a node according to the priority level of forwarded frames from upstream station, multicast/broadcast frames and transmitted frame from the local station. If there are several frames to be sent in a node at the same time, the schedule unit will decide which frame will go first to the downstream along the ring.

3.26 **N_ct**: a count of retransmission used to Configuration Table Operation. All nodes on a ring will wait to be assigned ICT during engineering installation period. After issuing CT_Request frame, Node A will automatically send CT_Request frame again after retransmit Timer_ct (it is programmable) if Node A does not receive corresponding CT_Response frame. It is believed that Node B is not reachable after N times of retransmission (N_ct is programmable also). N_ct is also used by CUT operation.

3.27 **Network Management Frame**: a frame used to performance and fault monitoring, node configuration management etc in a node.

3.28 **Node Address (NA)**: an address of Node Link on the MSR ring. NA is a local address and has local meaning only along the MSR ring. It contains 4 octets. Each bit (binary "0" or "1") corresponds to a node. For example, the binary "00100000

00000000 00000000 00000000" stands for the 3rd Node Address (station), the binary "00000100 00000000 00000000 00000000" stands for the 6th Node Address (station) (refer to Figure 1). You may also use binary "00000010 00000000 00000000 00000000" to stand for 7th Node Address of new insertion and the actual number location of the 7th Node Address may be corresponded to middle position between Station 1 and Station 2 shown in Figure 1 since the MSR supports online node insertion. All Node Address must be leftward alignment and be pre-installed by (NVROM) before operation. The maximum node number of the MSR Ring is 32. For implementation, people can use Ethernet MAC and Ipv4 address to perform external network management.

3.29 Normal State: a state used to describe a node that has normal Tx and Rx function on MSR ring and does not work on L2PS State. In Normal State, forwarding means that received frame from westward on FWR will be forwarded to eastward on FWR.

3.30 Physical Signal Degrade (PSD): random or automatic, caused by a physical signal degrade (e.g. excessive block or bit error rate). Once it happens, L2PS will be applied on the failure span.

3.31 Physical Signal Failure (PSF): random or automatic, caused by a physical signal failure (e.g. fibre facility failure). Once it happens, L2PS will be applied on the failure span.

3.32 Reference Point G1: a reference point between Rx Framer and RX Filter. It stands for termination of processing of MAC/GMAC physical layer before MII/GMII, or/and stands for termination of processing of SDH/SONET regeneration and multiplex section in receive direction. Please refer to Figure 3 – 6.

3.33 Reference Point G2: a reference point between Tx Framer and TX Schedule. It stands for source of processing of MAC/GMAC physical layer before MII/GMII, or source of processing of SDH/SONET regeneration and multiplex section in transmit direction. Please refer to Figure 3 – 6.

3.34 Reference Point T1: a reference point between Tributary Rx Framer and MSR-LEP processor. It stands for termination of processing of MSR-LEP before encapsulation of physical tributary of MII/GMII/TCE etc. Please refer to Figure 3 – 6.

3.35 Reference Point T2: a reference point between Tributary Rx Framer and MSR-LEP processor. It stands for source of processing of MSR-LEP after stripping of physical tributary of MII/GMII/TCE etc. Please refer to Figure 3 – 6.

3.36 Rx Framer: an abstract of physical framer of Aggregate Pipe at Rx side, it stands for a framer of Gigabit Ethernet, 10G Ethernet, or physical layer framer of STM-1/OC-12, STM-16/OC-48, STM-64/OC-192 or STM-192/OC-768. If Aggregate Pipe is STM-16/OC-48 for example, the rate of signal channel at the Reference Point G1 (refer to Figure 2) is VC-4-16c/VC-3-48c in the parallel way (just like POS PHY level 3 or SPI-3 defined by OIF) before Filter unit. If Aggregate Pipe is Gigabit Ethernet for example, the rate and signal are GMII at the Reference Point G1.

3.37 Second Working Ring (SWR): an outer or inner ring on the MSR. It can be defined as one of two symmetric counter-rotating rings. Default configuration of Second Working Ring is set to inner ring. It is programmable and is also set to the outer ring when the First Working Ring is set to the inner ring. In the case of FWR fibre facility or node failure, Second Working Ring can be seen as bypass channel of First Working Ring.

3.38 SWR-Fibre-Cut: a parameter of L2PS_Request Frame, used to stand for status indication of single fibre cut on SWR.

3.39 Timer_ct: a Timer of retransmission used to Configuration Table Operation. All nodes on a ring will wait to be assigned ICT during engineering installation period. After issuing CT_Request frame, Node A will automatically send CT_Request frame again after retransmission Timer_ct (it is programmable) if Node A does not receive corresponding CT_Response frame. It is believed that Node B is not reachable after N_ct times of retransmission (N_ct is programmable also). N_ct is also used by CUT operation.

3.40 Timer_WTR: a Timer used to prevent L2PS oscillation, the L2PS can waits Timer_WTR period (its value is programmable) before MSR enters Normal State.

3.41 Tributary: an independent adding/dropping tributary channel to/from the MSR data nodes, just like a series "Private Line or Private Circuit for Renting from Carrier". Tributary can be an Ethernet, Gigabit Ethernet (defined in IEEE802.3) and TCE. The different tributary can be assigned to different priority (The bandwidth of aggregate pipe depends on deployment service requirements the aggregate Tributary bandwidth be half the aggregate pipe bandwidth to provide protection bandwidth availability where needed. Where services requirements allow the aggregate Tributary bandwidth can exceed the aggregate bandwidth).

3.42 Tributary Adaptation Function Unit: an adaptation function from/to various independent tributary type signals to/from reference point T1/T2. It has Tributary Adaptation Source Function and Tributary Adaptation Sink Function. Sink corresponds to reference point T1, source to reference point T2. This adaptation function can include the signal and rate transform, synchronous function between two sides.

3.43 Tributary Cross-connection Relationship (TCCR): a table reflecting Tributary cross-connection relationship of all nodes on MSR ring. It is global table of MSR, that is, source and sink relationship of all available Tributaries.

3.44 Tributary Rx Framer: an abstract of physical framer of Tributary at Rx side, it stands for a framer of Gigabit Ethernet, Ethernet (10/100Mb/s) and TCE framers. If Tributary is Ethernet for example, the data at the Reference Point T1 is the payload of Ethernet MAC frame and interface is MII.

3.45 Tributary Tx Framer: an abstract of physical framer of Tributary at Tx side, it stands for a framer of Gigabit Ethernet, Ethernet (10/100Mb/s) and TCE framers. If Tributary is Ethernet for example, the data at the Reference Point T2 is the payload of Ethernet MAC frame and interface is MII.

3.46 Tributary Number (TN): a number of same type of Tributary Port on a node. This number is 7 if the 7th Ethernet is provided in a node. Please refer to Table 4.

3.47 Tributary Type (TT): a type of an independent adding/dropping tributary channel to/from the MSR data nodes. This type can be Ethernet, Gigabit Ethernet and TCE etc. Please refer to Table 4.

3.48 Topology Discovery: A data link control function in the MSR-LEP, used to find out who is its neighbor and how many nodes is been working on the MSR (to ensure transmitted frame must be received by same station, destination address of frame is pointed to itself). Each station appends its NA as parameter to this Topology Discovery Frame by order, update the length of parameter and passes this frame to the neighbor along the MSR ring as shown in Table 6. It is not necessary to know what is mapping relationship between Node Address and the physical position along FWR and SWR. Each node performs topology discovery function periodically (The value of Timer is programmable) by sending topology discovery frame on the first or second working ring. Topology Discovery uses a signalling format in Figure 9.

3.49 Time to Live: this 6-bit field is a hop-count that must decremented every time a node forwards a frame. The maximum number of nodes in a MSR ring specified in the patent is 32. In the wrapped case, the total node space can be 64 nodes on a ring.

3.50 Tx Framer: an abstract of physical framer of Aggregate Pipe at Tx side, it stands for a framer of Gigabit Ethernet, 10G Ethernet, physical layer framer of STM-1/OC-12, STM-16/OC-48, STM-64/OC-192, STM-192/OC-768. If Aggregate Pipe is STM-16/OC-48 for example, the rate and signal at the Reference Point G2 (refer to Figure 2) are VC-4-16c/VC-3-48c in the parallel way (just like POS PHY level 3 or SPI-3 defined by OIF) before Filter unit. If Aggregate Pipe is Gigabit Ethernet for example, the rate and signal are GMII at the Reference Point G2.

3.51 Wait to Restore (WTR): random or automatic, activated after the node entered L2 protection switching meets the restoration criteria once the condition of the PSF, PSD or fibre facility failure disappears. To prevent L2PS oscillation, the L2PS can waits Timer_WTR period (its value is programmable) before MSR enters Normal State.

3.52 WTR_Request Frame: a frame used to transition to Normal State from L2PS State. After the node entered L2PS meets the restoration criteria once the condition of

the PSF, PSD or fibre facility failure disappears. To prevent L2PS oscillation, the L2PS entity can waits Timer_WTR period (its value is programmable) to enter Normal State by using this frame.

4 Abbreviations

4.1 Abbreviations specified in IEEE 802.3

This Patent makes use of the following abbreviations specified in IEEE 802.3:

a) LAN Local area network

b) MAC Media access control.

c) MII Media Independent Interface.

d) GE Gigabit Ethernet

4.2 Abbreviations specified in ITU-T Recommendation G.707

This Patent makes use of the following abbreviations specified in ITU-T Recommendation G.707:

a) SDH Synchronous Digital Hierarchy

b) STM Synchronous Transfer Module

c) VC Virtual Container.

4.3 Abbreviations specified in ITU-T I.321 and I.361

This Patent makes use of the following abbreviations specified in ITU-T Recommendation:

a) ATM Asynchronous Transfer Mode

4.4 Abbreviations specified in ETSI

This Patent makes use of the following abbreviations specified in ETSI Recommendation EN 300 429:

a) DVB Digital Video Broadcast

4.5 Abbreviations specified in IETF

This Patent makes use of the following abbreviations specified in IETF RFC2615:

a) PPP Point-to-point Protocol

b) POS Packet Over SONET/SDH

4.6 Abbreviations specified in ANSI

This Patent makes use of the following abbreviations specified in ANSI T1.105-1991:

a) SONET Synchronous Optical Network

4.7 Abbreviations specified in this Patent

1) FWR First Working Ring

2) CS&NM Control Signalling and Network Management

3) CT Configuration Table

4) CTI Configuration Table Inquiry

5) CUT Configuration Updating Table

6) DL Data Link

7) ETBP Ethernet Tributary Based Protection

8) GMAC Gigabit Ethernet Media Access Control

9) ICT Initial Configuration Table

10) L2PS Layer 2 Protection Switch

11) MAC Media Access Control

12) MDL Layer Management of Data Link

13) MSR Multiple Services Ring

14) MSR LEP Multiple Services Ring –Link Encapsulation Protocol

15) PDU Protocol Data Unit

16) PPPoE PPP over Ethernet

17) PPPoA	PPP over ATM
18) PSD	Physical Signal Degrade
19) PSF	Physical Signal Failure
20) NA	Node Address
21) Rx	Receive data
22) SDU	Service Data Unit
23) ST	Source Tributary
24) SWR	Second Working Ring
25) TBM	Tributary Based Multicast
26) TBP	Tributary Based Protection
27) TCCR	Tributary Cross-Connection Relationship
28) TCE	TDM Circuit Emulation
29) TDM	Time Division Multiplex
30) TTBP	TCE Tributary Based Protection
31) TN	Tributary Number
32) TT	Tributary Type
33) Tx	Transmission data
34) WTR	Wait to Restore

5 MSR Network Framework

5.1 Elements of Ring

MSR is a bi-directional symmetric counter-rotating fibre rings consisted of at least two nodes (refer to Figure 1), each node could add and drop one or more independent Tributary (e.g. Ethernet, Gigabit Ethernet, TCE port, also could transmit and receive Layer 3 (Ipv4/Ipv6 packet) forwarding data packet (just like router), Control Signalling Frame and Network Management Frame. MSR supports multicast and broadcast of these Tributary service and forwarding data packet. Aggregate pipe can

be any kind of STM-4/OC-12, STM-16/OC-48, STM-64/OC-192, Gigabit Ethernet and 10Gigabit Ethernet. A node can be inserted or removed online from the ring while other nodes and services will be operated normally without packet loss and service loss.

5.2 Frame Types on a Ring and Multiple Service in Tributary

Each node has ability of adding and dropping one or more independent Tributary services defined in Table 1.

TABLE 1 – Types of multi-service in Tributary

Tributary types	CAPABILITIES		
Ethernet (specified in IEEE802.3)	Full duplex point-to-point	Multicast	Broadcast
GE (specified in IEEE802.3)	Full duplex point-to-point	Multicast	Broadcast
TCEs	Full duplex point-to-point	Multicast	Broadcast

Note 1: The bandwidth of aggregate pipe depends on deployment service requirements the aggregate Tributary bandwidth be half the aggregate pipe bandwidth to provide protection bandwidth availability where needed. Where services requirements allow the aggregate Tributary bandwidth can exceed the aggregate bandwidth.

Note 2: Multicast is half duplex point-to-multipoint of node based, Broadcast is half duplex point of node based to all other points on a ring.

Note 3: The mechanism of Ethernet/GE over SDH/SONET transport along MSR ring is almost the same as that of ITU-T Recommendation X.86/Y.1323 when LAPS is replaced by MSR-LEP in the protocol stack.

Transmitted and received frames on a ring have four types: frames of multi-service to Tributary, Layer 3 (Ipv4/Ipv6 packet) forwarding data packet (just like router), Control Signalling Frame and Network Management Frame specified in Table 2. They have full capabilities of point-to-point, multicast and broadcast along a ring.

TABLE 2 – Frame types

Frame types	CAPABILITIES		
Frames of multi-service to Tributary	Point-to-point	Multicast	Broadcast
Layer 3 (Ipv4/Ipv6 packet) forwarding data packet (a node operates just like a router)	Point-to-point	Multicast	Broadcast
Control Signalling Frame	Point-to-point	Multicast	Broadcast
Network Management Frame	Point-to-point	Multicast	Broadcast
Node: multicast and broadcast are of operation of node based.			

Fig. 2 illustrates Tx and Rx Function Diagram of MSR Data Node of the invention.

5.3 Components of Data Node

A MSR data node is the system equipment that has an eastward Rx, eastward Tx, westward Rx and westward Tx Aggregate Pipe connections, and one or more adding and dropping independent Tributaries. A MSR data node also has functions of receiving, transmitting and forwarding of network management frame, control signalling and data frame in a Node. The basic components of a MSR data node are as follows:

5.3.1 Aggregate Pipe: two symmetric counter fibre channels used to connect adjacent MSR data nodes along the First and Second Working Ring. The Aggregate Pipes are SDH/SONET and/or GE/10GE. In the SDH/SONET implementation, the Aggregate pipe is a channel of STM-16/OC-48, STM-64/OC-192, contiguous concatenation of 16 VC4 or 48VC3 or 64 VC4 or 192 VC3, or virtual concatenation of a set of VC4 or VC3. In the GE/10GE implementation, the Aggregate Pipe is GE or 10Gigabit Ethernet. It is recommended that the same bandwidth of Aggregate Pipe in

different span along the same ring is required. When SDH/SONET is applied to Aggregate Pipe, the overhead and other specifications of regeneration, multiplex section and high-order VC specified in ITU-T G.707 is used.

5.3.2 **Tributary**: an independent adding/dropping tributary channel to/from the MSR data nodes, just like a series "Private Line or Private Circuit for Renting from Carrier". Tributary can be an Ethernet, Gigabit Ethernet (defined in IEEE802.3) and TCE port. The different tributary can be assigned to different priority.

5.3.3 **First Working Ring (FWR)**: an outer or inner ring on the MSR. It can be defined as one of two symmetric counter-rotating rings. Default configuration of FWR is set to outer ring. It is programmable and can be changed to the inner ring.

5.3.4 **Second Working Ring (SWR)**: an outer or inner ring on the MSR. It can be defined as one of two symmetric counter-rotating rings. Default configuration of SWR is set to inner ring. It is programmable and is also set to the outer ring when the FWR is set to the inner ring. In the case of fibre facility or node failure, SWR can be seen as bypass channel of First Working Ring. But in normal case, it is working channel also.

5.3.5 **MSR filter Unit**: a filtering and checking facility for frame NA and TTL. All frames reaching to the MSR filter Unit will be sent first to a buffer in the Node. The MSR data node will check frame TTL and NA and perform XOR function with local NA. This frame will be taken away if TTL is zero. If its NA is match, those frames reaching destination will not be sent to neighbor (except for multicast and broadcast frames) along the same ring. Otherwise, those mismatched frame will go to neighbor directly by schedule unit without any processing after decrementing TTL field. This is MSR filtering function.

5.3.6 **MSR Schedule Unit**: a control function for transmitted frame in a node according to the priority level of forwarded frames from upstream station, multicast/broadcast frames and transmitted frame from the local station. If there are several frames to be sent in a node at the same time, the schedule unit will decide which frame will go first to the downstream along the ring.

5.3.7 **Rx Framer**: an abstract of physical framer of Aggregate Pipe at Rx side, it stands for a framer of Gigabit Ethernet, 10G Ethernet, or physical layer framer of STM-1/OC-12, STM-16/OC-48, STM-64/OC-192 or STM-192/OC-768. If Aggregate Pipe is STM-16/OC-48 for example, the rate of signal channel at the Reference Point G1 (refer to Figure 2) is VC-4-16c/VC-3-48c in the parallel way (just like POS PHY level 3 or SPI-3 defined by OIF) before Filter unit. If Aggregate Pipe is Gigabit Ethernet for example, the rate and signal are GMII at the Reference Point G1.

5.3.8 **Tx Framer**: an abstract of physical framer of Aggregate Pipe at Tx side, it stands for a framer of Gigabit Ethernet, 10G Ethernet, physical layer framer of STM-1/OC-12, STM-16/OC-48, STM-64/OC-192, STM-192/OC-768. If Aggregate Pipe is STM-16/OC-48 for example, the rate and signal at the Reference Point G2 (refer to Figure 2) are VC-4-16c/VC-3-48c in the parallel way (just like POS PHY level 3 or SPI-3 defined by OIF) before Filter unit. If Aggregate Pipe is Gigabit Ethernet for example, the rate and signal are GMII at the Reference Point G2.

5.3.9 **Tributary Rx Framer**: an abstract of physical framer of Tributary at Rx side, it stands for a framer of Gigabit Ethernet, Ethernet (10/100Mb/s) and TCE framers. If Tributary is Ethernet for example, the data at the Reference Point T1 is the payload of Ethernet MAC frame and interface is MII.

5.3.10 **Tributary Tx Framer**: an abstract of physical framer of Tributary at Tx side, it stands for a framer of Gigabit Ethernet, Ethernet (10/100Mb/s) and TCE framers. If Tributary is Ethernet for example, the data at the Reference Point T2 is the payload of Ethernet MAC frame and interface is MII.

5.4 Reference Point in Data Node

The four different Reference Points are defined in a node.

5.4.1 **Reference Point G1**: a reference point between Rx Framer and RX Filter. It stands for termination of processing of MAC/GMAC physical layer of Aggregate Pipe implemented with GE or 10GE before MII/GMII, or/and stands for termination

of processing of SDH/SONET regeneration and multiplex section of Aggregate Pipe implemented with SDH/SONET in receive direction. Please refer to Figures 3 – 6.

5.4.2 Reference Point G2: a reference point between Tx Framer and TX Schedule. It stands for source of processing of MAC/GMAC physical layer of Aggregate Pipe implemented with GE or 10GE before MII/GMII, or source of processing of SDH/SONET regeneration and multiplex section of Aggregate Pipe implemented with SDH/SONET in transmit direction. Please refer to Figures 3 – 6.

5.4.3 Reference Point T1: a reference point between Tributary Rx Framer and MSR-LEP Rx processor. It stands for termination of processing of MSR-LEP before encapsulation of physical tributary of MII/GMII/TCE etc. Please refer to Figures 3 – 6.

5.4.4 Reference Point T2: a reference point between Tributary Tx Framer and MSR-LEP Tx processor. It stands for source of processing of MSR-LEP after stripping of physical tributary of MII/GMII/TCE etc. Please refer to Figures 3 – 6.

5.5 Data Flow of Tx and Rx to Tributary

5.5.1 Rx direction: Rx frames entering a node at the Reference Point G1 are sent to Rx Filter Unit after performing Rx framer. Rx Filter Unit will check and filter TTL, FCS and NA of frame. All frames reaching to the MSR Filter Unit will be sent first to a buffer in the Node. The MSR Filter Unit will check TTL, FCS and NA of frame and perform XOR function with local NA. This frame will be taken away and discarded if TTL is zero or FCS is error.

If its NA is match, those frames reaching destination will not be sent to neighbor along the same ring (e.g. FWR). Otherwise, those mismatched frame will go to neighbor directly by schedule unit without any processing after decrementing TTL field.

If the received frame is multicast or broadcast frames, it will be sent first to Tx Schedule Unit to downstream node after decrementing TTL field, and it is coped to other buffer for further related processing in the local node at the same time.

After checked the aspects of TTL, NA and multicast/broadcast, a frame to reach destination is operated second procedure in the local node (station). That is, are

TT and TN illegal? If yes, this frame will be discarded. If no, this will be transferred to the corresponding Tributary port, Layer 3 forwarding unit, control signalling unit or network management unit at the Reference Point T1 according its value of TT and TN.

5.5.2 Tx direction: Rx frames entering a MSR-LEP Tx processor from a Tributary port, Layer 3 forwarding unit, control signalling unit or network management unit at the Reference Point T2,

will be got TTL, TCS, TT, TN values and multicast/broadcast requirement first, and then got NA value according to types and ports configuration of Tributary, a route of Layer 3 forwarding packet, requirement of control signalling or requirement of network management. After that, these frames will be sent to TX Schedule Unit. There are three types input: multicast/broadcast frames from upstream from other node, point-to-point frame for transferring from upstream and transmitted frame from local station. They are all went into TX Schedule Unit. Schedule Unit will operate a control function for these transmitted frames in a node according to the priority level of these frames. If there are several frames to be sent in a node at the same time, the schedule unit will decide which frame will go first to the downstream along the ring. It is also possible to discard those frames of lower priority level during burst Tx period.

5.6 Operation of Layer 3 forwarding Packets

MSR data node can be used as a router to forward route packets to other node on MSR ring according to relationship between Ipv4/Ipv6 routing table and its NA/TT/TN while this node could provide Tributary port for renting just like private line or circuit. When MSR data node is taken a role of router, the control plan (e.g. operation of routing protocols), network management plan (e.g. Simple Network Management Protocol) and traffic plan of said router (MSR data node) will share the same logical channel corresponding to the value of NA, TT and TN along the ring. That is, the control signalling frames of said router (MSR data node) will be operated on the different channel from the control signalling frames of MSR ring.

5.7 Operation of Control Signalling Frames

5.7.1 Operation of Topology Discovery Frame

5.7.1.1 Operation of Topology Discovery Frame in normal state

Topology Discovery Frame is a control frame in the MSR-LEP, used to figure out who is its neighbor and how many nodes are been working on the MSR (to ensure transmitted frame must be received by same station sending Topology Discovery Frame, destination address of frame is pointed to itself). Periodically (Timer_topology_discovery defaults to 3 seconds and is programmable), each station (e.g. Node A) broadcasts Topology_Discovery_Request Frame with a Null parameter along a FWR and SWR respectively. All stations (e.g. Node B) received Topology_Discovery_Request Frame give a response by Topology_Discovery_Response Frame with a local NA (e.g. NA of Node B) to that station (e.g. Node A). Node A appends received NA and TTL value to its Topology Address Library in Node A by order of stations after getting Topology_Discover_Response frame. The order of stations along a ring is dependent on difference of TTL value. TTL value, state (Normal State or L2PS State) of Node B, Ring state (Normal State or L2PS State) and value of FWR/SWR are bound to NA of Node B together as a record of Topology Address Library in Node A. The maximum and minimum values of TTL in a record of FWR or SWR correspond to two adjacent neighbors of Node A. The records of Topology Address Library of FWR and SWR are operated separately.

The operation of topology discovery frame is valid and topology status in a node is refreshed if the same results are got after consecutive 3 times transmission of topology discovery frame. Otherwise, the previous record of topology status will be kept unchanged. The operation and record of FWR and SWR topology discovery in a node are carried out separately.

5.7.1.2 Operation of Topology Discovery Frame in the case of FWR Fibre Cut

The MSR-LEP does work by sending both data frame and the associated network management/control frames in FWR, sending both data frame and the associated network management /control frames in SWR also.

If single fibre is cut or PSF occurs on FWR from Node 1 to Node 2 in Figure 1 for example, Node 2 detects PSF on FWR. Node 1 and Node 2 enter L2PS state from Node 1 to Node 2 on FWR and an L2PS_Event_Report Frame is broadcasted to all stations in a ring. At this moment, data frame and the corresponding network management /control frames in SWR, Node 3, 4, 5 and 6 are kept in normal state as usually. Periodically (Timer_topology_discovery defaults to 3 seconds and is programmable), any station of Node 1, 2, 3, 4, 5 and 6 (e.g. Node C) broadcasts Topology_Discovery_Request Frame with a Null parameter along a FWR first. When and if it reaches Node 1 or Node 2, or transmitted from Node 1 to Node 2, the route of this Topology_Discovery_Request Frame will be changed to SWR in the opposite direction. If FWR is involved in L2PS state, TTL value of those nodes sending frame and not being in L2PS state on SWR should be double of that in normal state when a frame is sent from these nodes. All stations (e.g. Node D) received Topology_Discovery_Request Frame give a response by Topology_Discovery_Response Frame with a local NA (e.g. NA of Node D) to that station (e.g. Node C). Node C appends received NA and TTL value to its Topology Address Library in Node C by order of stations. The order of stations along a ring is dependent on difference of TTL value. TTL value, state (Normal State or L2PS State) of Node D, state of ring (Normal State or L2PS State) and value of FWR/SWR are bound to NA of Node D together as a record of Topology Address Library in Node C. The maximum and minimum values of TTL in a record of FWR or SWR correspond to two neighbors of Node C. The records of Topology Address Library of SWR and FWR are operated separately.

5.7.1.3 Operation of Topology Discovery Frame in the case of SWR Fibre Cut

If single fibre is cut or PSF occurs on SWR from Node 2 to Node 1 in Figure 1 for example, Node 1 detects PSF on SWR. Node 2 and Node 1 enter L2PS state from Node 2 to Node 1 on SWR and an L2PS_Event_Report Frame is broadcasted to all

stations in a ring. At this moment, data frame and the corresponding network management /control frames in SWR, Node 3, 4, 5 and 6 are kept in normal state as usually. Periodically (Timer_topology_discovery defaults to 3 seconds and is programmable), any station of Node 1, 2, 3, 4, 5 and 6 (e.g. Node C) broadcasts Topology_Discovery_Request Frame with a Null parameter along a SWR first. When and if it reaches Node 2 or Node 1, or transmitted from Node 2 to Node 1, the route of this Topology_Discovery_Request Frame will be changed to FWR in the opposite direction. If SWR is involved in L2PS state, TTL value of those nodes sending frame and not being in L2PS state on SWR should be double of that in normal state when a frame is sent from these nodes. All stations (e.g. Node D) received Topology_Discovery_Request Frame give a response by Topology_Discovery_Response Frame with a local NA (e.g. NA of Node D) to that station (e.g. Node C). Node C appends received NA and TTL value to its Topology Address Library in Node C by order of stations. The order of stations along a ring is dependent on difference of TTL value. TTL value, state (Normal State or L2PS State) of Node D, state of ring (Normal State or L2PS State) and value of FWR/SWR are bound to NA of Node D together as a record of Topology Address Library in Node C. The maximum and minimum values of TTL in a record of FWR or SWR correspond to two neighbors of Node C. The records of Topology Address Library of SWR and FWR are operated separately.

5.7.1.4 Operation of Topology Discovery Frame in the case of Bidirectional Fibre Cut

If bidirectional fibre are cut or PSF occurs on both FWR and SWR from Node 1 to Node 2 in Figure 1 for example, Node 1 and Node 2 detect PSF on SWR and FWR respectively. Node 1 and Node 2 enter L2PS state from Node 1 to Node 2 on FWR and from Node 2 to Node 1 on SWR, and an L2PS_Event_Report Frame is broadcasted to all stations in a ring. At this moment, Node 3, 4, 5 and 6 are kept in normal state as usually. Periodically (Timer_topology_discovery defaults to 3 seconds and is programmable), any station of Node 1, 2, 3, 4, 5 and 6 (e.g. Node C) broadcasts Topology_Discovery_Request Frame with a Null parameter along both FWR and

SWR. When and if it reaches Node 1 or Node 2, or transmitted from Node 1 to Node 2, the route of this Topology_Discovery_Request Frame will be changed from FWR to SWR or from SWR to FWR in the opposite direction. If both FWR and SWR are involved in L2PS state, TTL value of those nodes sending frame and not being in L2PS state on both FWR and SWR should be double of that in normal state when a frame is sent from these nodes. All stations (e.g. Node D) received Topology_Discovery_Request Frame give a response by Topology_Discovery_Response Frame with a local NA (e.g. NA of Node D) to that station (e.g. Node C). Node C appends received NA and TTL value to its Topology Address Library in Node C by order of stations. The order of stations along a ring is dependent on difference of TTL value. TTL value, state (Normal State or L2PS State) of Node D, state of ring (Normal State or L2PS State) and value of FWR/SWR are bound to NA of Node D together as a record of Topology Address Library in Node C. The maximum and minimum values of TTL in a record of FWR or SWR correspond to two neighbors of Node C. The records of Topology Address Library of SWR and FWR are operated separately.

5.7.1.5 Operation of Topology Discovery Frame in the case of Bidirectional Failure on Both Sides of Node

If bidirectional Failure on Both Sides of Node 2 for example, Node 1 and Node 3 detect PSF on SWR and FWR respectively. Node 1 and Node 3 enter L2PS state from Node 1 to Node 3 on FWR and from Node 3 to Node 1 on SWR, and an L2PS_Event_Report Frame is broadcasted to all stations in a ring. At this moment, Node 4, 5 and 6 are kept in normal state as usually. Periodically (Timer_topology_discovery defaults to 3 seconds and is programmable), any station of Node 1, 3, 4, 5 and 6 (e.g. Node C) broadcasts Topology_Discovery_Request Frame with a Null parameter along both FWR and SWR. When and if it reaches Node 1 or Node 3, or transmitted from Node 1 to Node 3, the route of this Topology_Discovery_Request Frame will be changed from FWR to SWR or from SWR to FWR in the opposite direction. If both FWR and SWR are involved in L2PS state, TTL value of those nodes sending frame and not being in L2PS state on both

FWR and SWR should be double of that in normal state when a frame is sent from these nodes. All stations (e.g. Node D) received Topology_Discovery_Request Frame give a response by Topology_Discovery_Response Frame with a local NA (e.g. NA of Node D) to that station (e.g. Node C). Node C appends received NA and TTL value to its Topology Address Library in Node C by order of stations. The order of stations along a ring is dependent on difference of TTL value. TTL value, state (Normal State or L2PS State) of Node D, state of ring (Normal State or L2PS State) and value of FWR/SWR are bound to NA of Node D together as a record of Topology Address Library in Node C. The maximum and minimum values of TTL in a record of FWR or SWR correspond to two neighbors of Node C. The records of Topology Address Library of SWR and FWR are operated separately.

5.7.2 Operation of Manual Switch and Forced Switch Frames

L2PS_Request frame with a Manual_Switch or Forced_Switch parameter targeting one or two spans on MSR ring is sent to other nodes by unicast or multicast mode from a node (called Node A, e.g. Central station in the most case) by network management interface during initial engineering operation period. All nodes (called Node B) received L2PS_Request frame will perform corresponding switching operation in the adjacent nodes (Node B and C) of targeted span and give a point-to-point response by L2PS_Response frame with a parameter of Successful_Switch or Unsuccessful_Switch to Node A, and issues L2PS_Event_Report frame with a set parameters of Forced_Switch/Manual_Switch and L2PS-State to designated node (connected to Network management) and/or broadcasts to all stations in normal state in a ring. It is successful operation if Node A receives two correct responses from both Node B and Node C. Otherwise, it is not successful operation.

5.7.3 Operation of L2PS in the case of PSF/PSD and Node failure

5.7.3.1 Operation of FWR Fibre Cut

If single fibre is cut or PSF occurs on FWR from Node 1 to Node 2 in Figure 1 for example, Node 2 detects PSF on FWR. That is, neither flag nor frame is received within 30ms (the values of T200 and N200 are programmable) in the FWR of short

path. L2PS entity in a Node 2 will start L2PS function and perform following sub-functions:

(1)Node 2 goes into L2PS State and passes L2PS_Request Frame with a parameter of FWR_Fibre_Cut along short path of SWR to Node 1. After getting this frame, Node 1 enters L2PS State also, and issues L2PS_Event_Report frame with a set parameters of SWR_Fibre_Cut/FWR_Fibre_Cut, PSF/PSD and L2PS-State to designated node (connected to Network management) and/or broadcasts to all stations in normal state in a ring. In L2PS State, all frames from Node 1 to Node 2 along short path of FWR are switched to the long path of SWR in opposite direction.

(2)When PSF on Node 2 clears, Node 2 goes to Normal State, starts Timer_WTR (it is programmable). Once Timer_WTR expires, Node 2 sends WTR-Request Frame with a parameter of Successful_WTR to Node 1 along both short path and the long path at once. Node 1 goes back to Normal State from L2PS State after receiving this frame.

5.7.3.2 Operation of SWR Fibre Cut

If single fibre is cut or PSF occurs on SWR from Node 2 to Node 1 in Figure 1 for example, Node 1 detects PSF on SWR. That is, neither flag nor frame is received within 20ms (its value is programmable) in the SWR of short path. L2PS entity in a Node 1 will start L2PS function and perform following sub-functions:

(1)Node 1 goes into L2PS State and passes L2PS_Request Frame with a parameter of SWR-Fibre-Cut along short path of FWR to Node 2. After getting this frame, Node 2 enters L2PS State also, and issues L2PS_Event_Report frame with a set parameters of SWR_Fibre_Cut/FWR_Fibre_Cut, PSF/PSD and L2PS-State to designated node (connected to Network management) and/or broadcasts to all stations in normal state in a ring. In L2PS State, all frames from Node 2 to Node 1 along short path of SWR are switched to the long path of FWR in opposite direction.

(2)When PSF on Node 1 clears, Node 1 goes to Normal State, starts Timer_WTR (it is programmable). Once Timer_WTR expires, Node 1 sends WTR-Request Frame with a parameter of Successful_WTR to Node 2 along both short path of SWR and

the long path of FWR at once. Node 2 goes back to Normal State from L2PS State after receiving this frame.

5.7.3.3 Operation of Bidirectional Fibre Cut

If bidirectional fibre is cut or PSF occurs on both FWR and SWR from Node 1 to Node 2 in Figure 1 for example, Node 1/Node 2 detects PSF on SWR/FWR. That is, neither flag nor frame is received within 20ms (its value is programmable) in both FWR and SWR of short path. L2PS entity in both Node 1 and Node 2 will start L2PS function and perform following sub-functions:

(1)Node 1/Node 2 goes into L2PS State itself and passes L2PS_Request Frame with a parameter of SWR_Fibre_Cut/FWR_Fibre_Cut along the long path of FWR/SWR to Node 2/Node 1. After getting this frame, both Node 2 and Node 1 enters L2PS State, and issues L2PS_Event_Report frame with a set parameters of SWR_Fibre_Cut/FWR_Fibre_Cut, PSF/PSD and L2PS-State to designated node (connected to Network management) and/or broadcasts to all stations in normal state in a ring. In L2PS State, all frames from Node 1 to Node 2 or from Node 2 to Node 1 along short path of FWR/SWR are switched to the long path of SWR/FWR in opposite direction.

(2)When PSF on Node 1 and Node 2 clears, Node 1 and Node 2 go to Normal State, starts Timer_WTR (it is programmable). Once Timer_WTR expires, Node 1/Node 2 sends WTR_Request Frame with a parameter of Successful_WTR to Node 2/Node 1 along the long path at once. Node 1/Node 2 goes back to Normal State from L2PS State after receiving this frame.

5.7.3.4 Operation of Bidirectional Failure on Both Sides of Node

Bidirectional Failure on Both Sides of Node is complete node failure. If it is Node 2 in Figure 1 for example, Node 1 and Node 3 detect PSF on both SWR and FWR. That is, neither flag nor frame is received within 20ms (its value is programmable) in both FWR and SWR of shorter path via Node 2. L2PS entity in both Node 1 and Node 3 will start L2PS function and perform following sub-functions:

(1)Node 1/Node 3 goes into L2PS State itself in both directions and passes L2PS_Request Frame with a parameter of SWR_Fibre_Cut/FWR_Fibre_Cut along the long path of FWR/SWR to Node 3/Node 1. After getting this frame, both Node 3 and Node 1 enters L2PS State in both directions, and issues L2PS_Event_Report frame with a set parameters of SWR_Fibre_Cut/FWR_Fibre_Cut, PSF/PSD and L2PS-State to designated node (connected to Network management) and/or broadcasts to all stations in normal state in a ring. In L2PS State of both directions, all frames from Node 1 to Node 3 or from Node 3 to Node 1 along shorter path of FWR/SWR are switched to the long path of SWR/FWR in opposite direction.

(2)When PSF on Node 1 and Node 3 clears or Node 2 is restored, Node 1 and Node 3 go to Normal State, starts Timer_WTR (it is programmable). Once Timer_WTR expires, Node 1/Node 3 sends WTR-Request Frame with a parameter of Successful_WTR to Node 3/Node 1 along the long path at once. Node 1/Node 3 goes back to Normal State from L2PS State after receiving this frame.

5.7.3.5 Operation of Bidirectional Failure on One Side of Node

This case is the same as 5.7.3.3.

5.8 Operation of Network Management Frames

5.8.1 Initial Configuration Table (ICT) Operation

ICT is a mapping table reflecting the initial and available value of TT and TN in a node and TCCR between nodes on the MSR ring during engineering installation. The ICT must be pre-installed by (NVROM or FLASH RAM) before MSR engineering operation. The incorrect ICT will lead to fault of Tributary services on MSR ring. CT_Request frame with an ICT parameter reflecting initial TCCR of all nodes on MSR ring is sent to other nodes by broadcast mode from a node (called Node A, e.g. Central station in the most case) by network management interface during initial engineering operation period. All nodes (called Node B) received CT_Request frame will build corresponding mapping relations of TCCR in the local node and give a point-to-point response by CT_Response frame to Node A.

All nodes on a ring will wait to be assigned ICT during engineering installation period. After issuing CT_Request frame, Node A will automatically send CT_Request frame again after retransmit timer (it is programmable, named for Timer_ct) if Node A does not receive corresponding CT_Response frame. It is believed that Node B is not reachable after N_ct times of retransmission (N_ct is programmable also).

If Node A has received a message of CT_Response frame with a Null parameter from Node B either before CT retransmit expired or before N_ct times of retransmission, it is believed that ICT operation for Node B is successful.

5.8.2 Configuration Updating Table (CUT) Operation

CUT is a mapping table reflecting the available value modification of TT and TN in a node and TCCR between nodes on the MSR ring during the engineering operation. The CUT is applied during MSR engineering operation. The incorrect CUT will lead to fault of Tributary on MSR ring. CT_Request frame with a CUT parameter reflecting changed part of TCCR of all nodes on MSR ring is sent to other nodes (called one of them Node B) by broadcast mode from a node (called Node A, e.g. Central station in the most case) by network management interface during normal engineering operation period. All nodes received CT_Request frame will build corresponding mapping relations of TCCR in the local node and give a point-to-point response by CT_Response frame to Node A.

All nodes on a ring will wait to be assigned IUT during the project engineering installation phase. After issuing CT_Request frame, Node A will automatically send CT_Request frame again after retransmit timer (it is programmable, named for Timer_ct) if Node A does not receive corresponding CT_Response frame. It is believed that Node B is not reachable after N_ct times of retransmission (N_ct is programmable also).

If Node A has received a message of CT_Response frame with a Null parameter from Node B either before CT retransmit expired or before N_ct times of retransmission, it is believed that CUT operation for Node B is successful.

5.8.3 Configuration Table Inquiry (CTI) Operation

CT_Request frame with a Null parameter is sent to other nodes (called one of them Node B) by unicast/multicast/broadcast mode from a node (called Node A, e.g. Central station in the most case) by network management interface during normal engineering operation period. All nodes received CT_Request frame with a Null parameter will give a point-to-point response by CT_Response frame with a CTI parameter reflecting actual configuration table of the local node on MSR ring to Node A.

5.9 Fault Management

If a fault occurs, Fault_Report frame with a fault parameter defined in 7.9.2 is sent to designated node (connected to network management interface). The network management entity can pass Fault_Request Frame with a fault parameter defined in 7.9.2 from designated node to a targeted node. The targeted node issues Fault_Response Frame with a fault parameter defined in 7.9.2 to designated node as a responding.

5.10 Performance Management

Once 15 minutes or 24 hours expired, each node in a ring will issue Performance_Report frame with a performance parameter defined in 7.9.2 to designated node (connected to network management interface). The network management entity can pass Performance_Request Frame with a performance parameter defined in 7.9.2 from designated node to a targeted node if needed anytime. The targeted node responds by Performance_Response Frame with a performance parameter defined in 7.9.2 to designated node.

6 The Protocol Framework of Aggregate Pipe

6.1 The protocol framework of SDH/SONET based Aggregate Pipe

Figure 3 is the protocol framework of MSR-LEP (Octet-oriented) of SDH/SONET aggregate pipe. It is the same as X.86/Y.1323 when LAPS is replaced by MSR-LEP. This Patent treats SDH transport as an octet-oriented synchronous point-to-point full-duplex link. The SDH frame is an octet-oriented synchronous multiplex mapping structure that specifies a series of standard rates, formats and mapping methods. The use of control signals is not required. The self-synchronous scrambling/descrambling ($x^{43}+1$) function is applied during insertion/extraction into/from the synchronous payload envelope. Communication service facilities between MSR-LEP (Octet-oriented) and physical layer are accomplished by means of primitives (PH-DATA request and PH-DATA indication) according to the principle of ITU-T Recommendation X.211. Specification of Primitives specifies the interaction between MSR-LEP and physical layer to invoke and provide a service, and presents the elements.

The data link protocol is MSR-LEP (Octet-oriented), which provides point-to-point transferring over SDH virtual containers (including contiguous concatenation or virtual concatenation) and interface rates. The supported MSR-LEP is connection-less-mode protocol. Communications between data link and the associated upper protocols are accomplished by means of primitives according to the principle of ITU-T Recommendation X.212.

The service facility of MSR-LEP (Octet-oriented) provided to other upper protocols via SAP (Service Access Point) is the DL-UNACK- DATA request primitive with "User data" (data frame in Tributary and L3 forwarding part or frame of CS & NM) and "Priority" parameter set in a node from configuration, and the DL-UNACK-DATA indication primitive with "User data" (data frame in Tributary and L3 forwarding part or frame of CS & NM) and "Priority" parameter from received frame. "User data" is the outgoing/incoming upper layer packet. The default maximum frame size of MSR-LEP shall be capable of supporting an information field of 1 600 octets (at least).

All frames start and end with the flag sequence consisting of one 0 bit followed by six contiguous 1 bits and one 0 bit. The flag preceding the destination node address field is defined as the opening flag. The flag following the Frame Check Sequence (4-octet FCS) field is defined as the closing flag. The closing flag also serves as the opening flag of the next frame, in some applications. However, all receivers shall be able to accommodate receipt of one or more consecutive flags. The Flag Sequence shall be transmitted during inter-frame time fill.

An octet stuffing procedure is applied for SDH/SONET Aggregate Pipe. Each frame begins and ends with the flag 0x7E. A transmitting data link layer entity of MSR-LEP (Octet-oriented) shall examine the frame content between the opening and closing flag sequences (Destination Node Address, Time to Live, U/M/B, FWR/SWR, Priority, TT, TN, CS & NM, Payload or CS & NM parameters, and FCS fields) during transmission; if the flag sequence occurs, it shall be converted to the sequence 0x7D 0x5E. Occurrence of 0x7D is transformed to 0x7D 0x5D also. At the receiver, the stuff patterns are removed and replaced with the original fields. An invalid frame is a frame which:

a) is not properly bounded by two flags; or

b) has fewer than sixteen octets between flags of frames; or

c) contains a FCS error; or

d) contains a NA, U/M/B, TT or TN which are mismatched or not supported by the receiver.

e) has an invalid control sequence, i.e. {0x7d, ZZ} where ZZ octet is not 5d, 5e, 7e.

Invalid frame shall be discarded without notification to the sender. No action is taken as the result of that frame.

FIGURE 3 illustrates protocol Stack of Ethernet over SDH/SONET using MSR-LEP in SDH/SONET based Aggregate Pipe

The connection management entity is used optionally to monitor the link status of receiving the peer link frame. It is local matter only and has not any associated frame to be used between the two sides.

--After initialization (the defaults of T200 and N200 are set to 10 milliseconds and 3 respectively), the MSR-LEP entity enters the normal way of transmitter and receiver.

--If the timer T200 expires before any frame (including data/CS & NM frame and inter- frame time fill) is received, the MSR-LEP entity shall restart timer T200 and decrement the retransmission counter N200.

--If timer T200 expires and retransmission counter N200 has been decremented to zero before any frame is received, the MSR-LEP entity shall indicate this to the local connection management entity by means of the MDL-ERROR indication primitive, and restart timer T200 and recover the value of N200. In the normal case of frame transmit and receive, the values of T200 and N200 will always be refreshed to maintain the initial defaults.

--The value of T200 and N200 shall be configurable. The minimum unit configured of T200 and N200 is 5 milliseconds and 1 respectively.

MSR-LEP (Octet-oriented) entity accepts frames from the MAC layer through the Reconciliation sublayer and an equivalent MII (Media Independent Interface). No address filtering function is used here. The format of MSR-LEP (Octet-oriented) payload field is defined in the shaded region of Figure 6 in ITU-T X.86/Y.1323. The order of those octets and bits shaded area as shown is kept intact. The function unit of MSR-LEP forwards all incoming MSR-LEP frames to its peer connected to link along a ring except the originating link port, and is permitted to buffer one or more incoming frames before forwarding them.

Protocol stack of IP over SDH/SONET using MSR-LEP (Octet-oriented) are shown in Figure 4. The reference point G1/G2 and T1/T2 is reflected in and is corresponded to Figure 2 and section 5.4.

FIGURE 4 illustrates protocol Stack of IP over SDH/SONET using MSR-LEP in SDH/SONET based Aggregate Pipe, it will be used to network management, control signalling and Layer 3 forwarding packet

6.2 The protocol framework of GE and 10GE based Aggregate Pipe

Figure 5 is the protocol framework of MSR-LEP (Bit-oriented) of GE and 10GE based. It has the same position as Logical Link Control protocol defined in IEEE802.2. This Patent treats MSR-LEP as a upper layer protocol of Ethernet MAC of point-to-point full-duplex. The use of control signals is not required. The self-synchronous scrambling/descrambling ($x^{43}+ 1$) function is not applied during insertion/extraction into/from the MAC payload. Communication service facilities between MSR-LEP (Bit-oriented) and MAC layer are accomplished by means of primitives (MAC-DATA request and MAC-DATA indication) according to the principle of ITU-T Recommendation X.211. Specification of Primitives specifies the interaction between MSR-LEP and MAC layer to invoke and provide a service, and presents the elements.

The supported MSR-LEP (Bit-oriented) is connection-less-mode protocol. Communications between data link and the associated upper protocols are accomplished by means of primitives according to the principle of ITU-T Recommendation X.212.

The service facility of MSR-LEP (Bit-oriented) provided to other upper protocols via SAP (Service Access Point) is the DL-UNACK- DATA request primitive with "User data" (data frame in Tributary and L3 forwarding part or frame of CS & NM) and "Priority" parameter set in a node from configuration, and the DL-UNACK-DATA indication primitive with "User data" (data frame in Tributary and L3 forwarding part or frame of CS & NM) and "Priority" parameter from received frame. "User data" is the outgoing/incoming upper layer packet. The default maximum frame size of MSR-LEP shall be capable of supporting an information field of 1 600 octets in this case.

The octet stuffing procedure will not be used in this case.

An invalid frame is a frame which:

a) is not properly bounded by two flags; or

b) has fewer than sixteen octets between flags of frames; or

c) contains a FCS error; or

d) contains a NA, U/M/B, TT or TN which are mismatched or not supported by the receiver.

Invalid frame shall be discarded without notification to the sender. No action is taken as the result of that frame.

The connection management entity is used optionally to monitor the link status of receiving the peer link frame. It is local matter only and has not any associated frame to be used between the two sides.

--After initialization (the defaults of T200 and N200 are set to 10 milliseconds and 3 respectively), the MSR-LEP entity enters the normal way of transmitter and receiver.

--If the timer T200 expires before any frame (including data/CS & NM frame and inter- frame time fill) is received, the MSR-LEP (Bit-oriented) entity shall restart timer T200 and decrement the retransmission counter N200.

--If timer T200 expires and retransmission counter N200 has been decremented to zero before any frame is received, the MSR-LEP (Bit-oriented) entity shall indicate this to the local connection management entity by means of the MDL-ERROR indication primitive, and restart timer T200 and recover the value of N200.

--The value of T200 and N200 shall be configurable. The minimum unit configured of T200 and N200 is 5 milliseconds and 1 respectively.

MSR-LEP entity accepts TCE upper layer frames from the upper layer (e.g. through the Reconciliation sublayer and an equivalent MII for Ethernet of upper layer). No address filtering function is used here. The format of MSR-LEP (Bit-oriented) payload field is defined in the shaded region of Figure 6 in ITU-T X.86/Y.1323. The order of those octets and bits shaded area as shown is kept intact. The function unit of MSR-LEP forwards all incoming MSR-LEP frames to its peer

connected to link along a ring except the originating link port, and is permitted to buffer one or more incoming frames before forwarding them.

Protocol stack of IP over GE or 10GE using MSR-LEP (Bit-oriented) are shown in Figure 6. The reference point G1/G2 and T1/T2 is reflected in and is corresponded to Figure 2 and section 5.4 also.

FIGURE 5 illustrates protocol Stack of Ethernet over GE or 10GE in GE or 10GE based Aggregate Pipe

FIGURE 6 illustates protocol Stack of IP over Ethernet in GE and 10GE based Aggregate Pipe, it will be used to network management, control signalling and Layer 3 forwarding packet

FIGURE 7 shows generic Protocol Stack of MSR

MSR can provide a set facility of access Ethernet (10/100Mb/s), Gigabit Ethernet, TCE and other MSR ring, Layer 3 packet forwarding and CS& NM over MSR-LEP as shown in Figure 7. Figure 7 is generic protocol framework of MSR, including MSR-LEP of octet-oriented and bit-oriented.

6.3 Tributary Adaptation Function Unit

Tributary Adaptation Function Unit is an adaptation function from/to various independent tributary type signals to/from reference point T1/T2. It has Tributary Adaptation Source Function and Tributary Adaptation Sink Function. Sink corresponds to reference point T1, source to reference point T2. This adaptation function can include the signal and rate transform, synchronous function between two sides.

7 Generic MSR Frame Format

Each MSR-LEP frame uses a fixed sized header. The generic frame format is shown

in Figure 8. All binary numbers in the following descriptions in this Patent are in Most Significant Bit to Least Significant Bit order, reading from left to right, then two-octet based from top to bottom. The octets are also transmitted from left to right; then two-octet based from top to bottom, unless otherwise indicated. The 32-bit FCS transmission order and computation method of MSR frame are required to use the convention specified in RFC 1662.

FIGURE 8 shows generic Frame Format of MSR

The said fields are described below.

7.1 Destination Node Address

This 32-bit field is an address of Node Link on the MSR ring. NA is a local address and has local meaning only along the MSR ring. It contains 4 octets. Each bit (binary "0" or "1") corresponds to a node. For example, the binary "00100000 00000000 00000000 00000000" stands for the 3rd Node Address (station), the binary "00000100 00000000 00000000 00000000" stands for the 6th Node Address (station) (refer to Figure 1). You may also use binary "00000010 00000000 00000000 00000000" to stand for 7th Node Address of new insertion and the actual number location of the 7th Node Address may be corresponded to middle position between Node 1 and Node 2 shown in Figure 1 since the MSR supports online node insertion. All Node Address must be leftward alignment and be pre-installed by (NVROM) before engineering operation. The maximum node number of the MSR Ring is 32. For implementation, people can use Ethernet MAC and Ipv4/Ipv6 address to perform external network management.

7.2 Time to Live

This 5-bit field is a count of hops that must be decremented every time of forwarding a frame from a node on MSR ring.

7.3 FWR/SWR Field

This single bit field indicates on which ring this frame is assigned to run. "0" and "1" stand for FWR and SWR respectively.

7.4 U/M/B Field

The U/M/B stands for Unicast/Multicast/Broadcast of node based. This 2-bit field is defined as Table 3.

TABLE 3 – Codes of U/M/B field

U/M/B	Codes
Reserved	00
Unicast	01
Multicast	10
Broadcast	11

7.5 Priority Field

This 3-bit field reflects priority level of MSR-LEP frame from 0 to 7. The value of priority is determined by manual setting of configuration using network management interface before engineering installation according to Service Level Agreement from carrier at the Tx side in a node. The larger the value is, the higher the priority is. It may also be modified online during service operation by using CT_Request and CT_Response frames.

7.6 Reserved Field

This 5-bit field is reserved for future use.

7.7 Tributary Type (TT) Field

This 16-bit field stands for a type of an independent adding/dropping tributary channel to/from the MSR data nodes, Layer 3 forwarding packet, Control Signalling

and Network management frame. Tributary channel can be Ethernet, Gigabit Ethernet and TCE etc. Its codes are as follows (see Table 4).

TABLE 4 – TT Codes

Tributary types	Code
Reserved	00000000
G.707 SDH circuit -- Transport of TU-11	00000001
G.707 SDH circuit -- Transport of TU-12	00000010
G.707 SDH circuit -- Transport of TU-2	00000011
Reserved for other SDH circuits	00000100-00001000
G.702 PDH circuit -- Synchronous circuit transport	00001001
G.702 PDH circuit -- Asynchronous circuit 1.544Mbit/s	00001010
G.702 PDH circuit -- Asynchronous circuit 2.048Mbit/s	00001011
G.702 PDH circuit -- Asynchronous circuit 6.312Mbit/s	00001100
G.702 PDH circuit -- Asynchronous circuit 8.448Mbit/s	00001101
G.702 PDH circuit -- Asynchronous circuit 34.368Mbit/s	00001110
G.702 PDH circuit -- Asynchronous circuit 44.736Mbit/s	00001111
G.702 PDH circuit -- Synchronous circuit 1.544Mbit/s	00010000
G.702 PDH circuit -- Synchronous circuit 2.048Mbit/s	00010001
G.702 PDH circuit -- Synchronous circuit 6.312Mbit/s	00010010
G.702 PDH circuit -- Synchronous circuit 8.448Mbit/s	00010011
G.702 PDH circuit -- Synchronous circuit 34.368Mbit/s	00010100
G.702 PDH circuit -- Synchronous circuit 44.736Mbit/s	00010101
Reserved for other PDH circuits	00010110-00011000
Video signal -- Distributive television services	00011000
Video signal -- Conversational services of bit rates higher than primary rates	00011001
Video signal -- Conversational services of p×64 kbit/s signals	00011010

Reserved for other Video signals	00011011-00011111
Voiceband signal -- 64 kbit/s A-law coded Recommendation G.711 signals	00100000
Voiceband signal -- 64 kbit/s μ-law coded Recommendation G.711 signals	00100001
Reserved for other Voiceband signals	00100010-100111
Digital channel supported by 64 kbit/s-based ISDN -- Transport of 64 kbit/s channel	00101000
Digital channel supported by 64 kbit/s-based ISDN -- Transport of 384, 1536 or 1920 kbit/s channel	00101001
Reserved for other TCEs	00101010-00101000
Ethernet (10/100Mb/s, specified in IEEE802.3)	00110100
GE (specified in IEEE802.3)	00110101
L3 Forwarding Packet	00110110
CS & NM Frame	00110111
Other MSR Tributary	00111000
Reserved	00111001-11111111
The higher octet (left octet) of TT is default set to "00000000" and reserved for future use.	

7.8 Tributary Number (TN) Field

This 16-bit field is a number of same type of Tributary Port within a node. TN is 7 (Hex 0x0007) if the 7th Ethernet is provided in front of panel in a node for example.

7.9 CS & NM Field

This 8-bit field is used to identify the types of control signalling and network management frame shown in Table 5.

TABLE 5 – Type of Control Signalling and Network Management Frame

CS&NM Frame Types	Code

MSR-LEP Data Frame (L3 forwarding packet is also included)	00000000
Topology_Discovery_Request Frame	00000001
Topology_Discovery_Response Frame	00000010
L2PS_Request Frame	00000011
L2PS_Response Frame	00000100
L2PS_Event_Report	00000101
WTR_Request Frame	00000110
CT_Request Frame	00000111
CT_Response Frame	00001000
Fault_Report Frame	00001001
Fault_Inquiry_Request Frame	00001010
Fault_Inquiry_Response Frame	00001011
Performance_Report Frame	00001100
Performance _Inquiry_Request frame	00001101
Performance _Inquiry_Response frame	00001110
SYNCHRONIZATION Request	00001111
SYNCHRONIZATION Confirm	00010000
CONNECTION_Request frame	00010001
CONNECTION_Confirm frame	00010010
DISCONNECTION_Request frame	00010011
DISCONNECTION_Confirm frame	00010100
MDL_ERROR_Indication Request management frame	00010101
L2PS_RECOVERY_EVENT_Report	00010110
Reserved	00010111-11111111
Node:SYNCHRONIZATION Request frame will have the highest priority of delivery and receiving for each station.	

7.10 Frame Sequence Number (FSN) Field

This 8-bit field is used to identify Frame Sequence Number (FSN) of Ethernet, GE, TCE data frames or IP related L3 forwarding packets in numbered modulo N_fsn=256 (default value, N_fsn is programmable and can be configured to change) from 0 to 255. The FSN field will be set to zero if the signalling control frames or network management frames appear.

7.10.1 Processing of data frame in the transmit side

The DL provides a sequence count value and a DL indication associated with each frame in the transmit side. The count value applied to FSN field starts with 0, is incremented sequentially to 255 and is numbered modulo 256. When the data link frames carrying Tributary payloads traverse a MSR, then may arrive destination station disorderly, or lost one or more frames. Due to this reason, it is required that frames must be delivered in order.

7.10.2 Processing of data frame in the receive side

The Data Link entity in the receive side must detect the lost or duplicated frames, and track the following status of dynamic data stream:

- Frame sequence number and count;
- Frame loss (if occur);
- Frame duplication (if occur).

There are two ways to solve the real-time processing problem, (1) try to reorder and sort into the correct order or (2) drop those disordering frames, when disordering case occurred. In implementation, these two methods should be all supported. If method (1) does not meet reliability transport and performance requirement still, the method (2) will be applied. Due to the limitation of native speed and acceptable delay of data link processing, this Patent does not support correction method for bit errors and frame losses. If the event of any lost or duplicated frame occurred, data link entity will report to the layer management entity by MDL-ERROR-Indication (see 11.3.2.2.3).

7.11 Payload

When Tributary or Node Layer 3 Forwarding Packet is applied, payload field is used to encapsulate upper layer protocols listed in Table 4. Payload is octet-oriented and its size is variable. The default maximum frame size shall be capable of supporting an information field of 1 600 octets (at least) for both IPv4-based and IPv6-based applications. Except for Tributary, the payload of Layer 3 forwarding packet, control signalling frame and network management is described below.

7.11.1 Node Layer 3 Forwarding Part

Layer 3 forwarding Packet is a packet used to forward data packet in a node. This packet is different from those packets of reaching all Tributary in a node, is also different from network management frames and control signalling frames. Logically, a MSR data node can be treated as a router of performing Layer 3 forwarding when a Layer 3 forwarding Packet is forwarded according to routing table and routing protocols of IPv4/IPv6 in a node from the node to other node along the MSR ring.

7.11.2 Control Signalling and Network Management Part

FIGURE 9 shows generic Format of CS & NM Frames

The MSR-LEP does work by sending both data frame and the associated network management/control frames in FWR, sending both data frame and the associated network management /control frames in SWR also. Generic format of CS & NM Frames is shown in Figure 9. The parameter field is 4-octet based. The difference of the parameter field indicates various control signalling and network management frames below. The first octet of parameters field is used to identify how many parameters are used by CS & NM frame. Each parameter following 1st octet consists of type (or tag), length and value of parameter. If the total octet number of parameters field is not based on 4-octet, the octet padding (Binary 00000000) will be used.

7.11.2.1 Topology Discovery Frame

The initial TTL value should be the total number of actual working stations and is determined by provisioning during project installation. The operation of

Topology_Discovery_Request and Topology_Discovery_Response Frame is shown in 5.7.1 and Table 6 gives a Null parameter. U/M/B field is set to broadcast and priority is 7 (highest).

Table 6 – Parameter Type of Topology_Discovery_Request and Topology_Discovery_Response Frames

Parameter type	**Value of Parameter Field**
Null	Binary "00000001 00000000 00000000 00000000 +00000000 (padding)"

7.11.2.2 Parameters of L2PS_Request Frame

The First and Second Parameter Type of L2PS_Request Frame has Forced Switch, PSF, PSD and Manual Switch. Its value is defined as Table 7 and Table 8. The corresponding operation can be got in 5.7.2 and 5.7.3.

Table 7 – First Parameter Type of L2PS_Request Frame

Parameter type	**Value of Parameter Field**
Forced_Switch	Binary "00000001 00000100 00000001 00000000"
PSF	Binary "00000001 00000011 00000001 00000000"
PSD	Binary "00000001 00000010 00000001 00000000"
Manual_Switch	Binary "00000001 00000001 00000001 00000000"

Table 8 – Second Parameter Type of L2PS_Request Frame

Parameter type	**Value of Parameter Field**
FWR_Fibre_Cut	Binary "00000001 00000110 00000001 00000000"
SWR_Fibre_Cut	Binary "00000001 00000101 00000001 00000000"

7.11.2.3 Parameters of L2PS_Response Frame

The Parameter Type of L2PS_Request Frame has Successful_Switch, or Unsuccessful_Switch. Its value is defined as Table 9. The corresponding operation can be got in 5.7.3.

Table 9 – Parameter Type of L2PS_Response Frame

Parameter type	Value of Parameter Field
Successful_Switch	Binary "00000001 00001000 00000001 00000000"
Unsuccessful_Switch	Binary "00000001 00000111 00000001 00000000"

7.11.2.4 Parameters of L2PS_Event_Report Frame

The Parameter Type of L2PS_Event_Report Frame has Successful_Switch, or Unsuccessful_Switch. Its value is defined as Table 10, Table 11 and Table 12. The corresponding operation can be got in 5.7.3.

Table 10 – First Parameter Type of L2PS_Event_Report Frame

Parameter type	Value of Parameter Field
Forced Switch	Binary "00000001 00000100 00000001 00000000"
PSF	Binary "00000001 00000011 00000001 00000000"
PSD	Binary "00000001 00000010 00000001 00000000"
Manual Switch	Binary "00000001 00000001 00000001 00000000"

Table 11 – Second Parameter Type of L2PS_ Event_Report Frame

Parameter type	Value of Parameter Field
FWR_Fibre_Cut	Binary "00000001 00000110 00000001 00000000"
SWR_Fibre_Cut	Binary "00000001 00000101 00000001 00000000"

Table 12 – Third Parameter Type of L2PS_ Event_Report Frame

Parameter type	Value of Parameter Field
L2PS_State	Binary "00000001 00001010 00000001 00000000"
Normal_State	Binary "00000001 00001001 00000001 00000000"

7.11.2.5 Parameters of WTR_Request Frame

The corresponding operation can be got in 5.7.3 and parameter is shown in Table 13.

Table 13 –Parameter Type of WTR_Request Frame

Parameter type	Value of Parameter Field
Successful_WTR	Binary "00000001 00001011 00000001 00000000"

7.11.2.6 CT_Request Frame

The major portion of CT is TCCR ID. A TCCR ID consists of TNi ID, 2-bit U/M/B field, 6-bit length field and one or more TNj ID. ID is value of identifier, TSi, TNj, TNk and TNm are the ith Tributary Number of same TT of Node n, the jth Tributary Number of same TT of Node o, the kth Tributary Number of same TT of Node p and the mth Tributary Number of same TT of Node q.

Fig. 10 shows Expressions of TN ID and TCCR ID

The ICT, CUT and Null parameters indicate three different operations: ICT, CUT and CTI. Its type and field are described below in Table 14.

Table 14 –Parameter Type of CT_Request Frame

Parameter type	Parameter Field
ICT	Binary "00000001 00100000 +" octet number of parameter"+"value of TCCR ID shown in Figure 10"
CUT	Binary "00000001 00100001 +" octet number of parameter"+"value of TCCR ID shown in Figure 10"
Null	Binary "00000001 00100011 00000001 00000000"

7.11. 2.7 CT_Response Frame

Null parameter is used by ICT and CUT operation. CTI parameter is followed by CTI operation.

Table 15 –Parameter Type of CT_Request Frame

Parameter type	Parameter Field
CTI	Binary "00000001 00100100 +" octet number of parameter"+"value of TCCR ID shown in Figure 10"
Null	Binary "00000001 00100011 00000001 00000000"

The corresponding operation can be got in 5.8 and parameter is shown in Table 15.

7.11. 2.8 Fault_Report Frame

Table 16 –Parameter Type of Fault_Report Frame

Parameter type	Parameter Field
PSF	Binary "00000001 00000011 00000001 00000000"
PSD	Binary "00000001 00000010 00000001 00000000"

The corresponding operation can be got in 5.9 and parameter is shown in Table 16.

7.11. 2.9 Parameter of Fault_Inquiry_Request Frame

Table 17 –Parameter Type of Fault_Inquiry_Request Frame

Parameter type	Parameter Field
Null	Binary "00000001 00100011 00000001 00000000"

The corresponding operation can be got in 5.9 and parameter is shown in Table 17.

7.11. 2.10 Parameter of Fault_Inquiry_Response Frame

Table 18 –Parameter Type of Fault_Inquiry_Request Frame

Parameter type	Parameter Field
PSF	Binary "00000001 00000011 00000001 00000000"
PSD	Binary "00000001 00000010 00000001 00000000"

The corresponding operation can be got in 5.9 and parameter is shown in Table 18.

7.11. 2.11 Parameter of Performance_Report Frame

Table 19 –Parameter Type of Performance_Report Frame

Parameter type	Parameter Field
A set of TNi in a node (designated)	Binary "00000001 01000000 +" octet number of parameter "+"value of TNi shown in Figure 10"
TNFCS_15m (Total Number of FCS in 15 minutes, 4octets, 4octets length)	Binary "00000001 01000001 00000100 "value of TNFCS-15m shown in Figure 10"
TNPL_15m (Total Number of Frame Loss in 15 minutes, 4octets length)	Binary "00000001 01000001 00000100 "value of TNPL-15m shown in Figure 10"
TNFCS_24h (Total Number of FCS in 24 hours, 5octets length)	Binary "00000001 01000001 00000101 "value of TNFCS-24h shown in Figure 10"
TNPL_24h (Total Number of Frame Loss in 24 hours, 5octets length)	Binary "00000001 01000001 00000101 "value of TNPL-24h shown in Figure 10"

The corresponding operation can be got in 5.10 and parameter is shown in Table 19.

7.11. 2.12 Parameter of Performance_Inquiry_Request Frame

Table 20 –Parameter Type of Performance _Inquiry_Request Frame

Parameter type	Parameter Field
A set of TNi in a node (designated)	Binary "00000001 01000000 +"octet number of parameter "+"value of TNi shown in Figure 10"

The corresponding operation can be got in 5.10 and parameter is shown in Table 20.

7.11. 2.13 Parameter of Performance_Inquiry_Response Frame

Table 21 –Parameter Type of Performance _Inquiry_Response Frame

Parameter type	Parameter Field
A set of TNi in a node (designated)	Binary "00000001 01000000 +" octet number of parameter"+"value of TNi shown in Figure 10"
TNFCS_15m (Total Number of FCS in 15 minutes, 4octets length)	Binary "00000001 01000001 00000100 "value of TNFCS-15m shown in Figure 10"
TNPL_15m (Total Number of Frame Loss in 15 minutes, 4octets length)	Binary "00000001 01000001 00000100 "value of TNPL-15m shown in Figure 10"
TNFCS_24h (Total Number of FCS in 24 hours, 5octets length)	Binary "00000001 01000001 00000101 "value of TNFCS-24h shown in Figure 10"
TNPL_24h (Total Number of Frame Loss in 24 hours, 5octets length)	Binary "00000001 01000001 00000101 "value of TNPL-24h shown in Figure 10"

The corresponding operation can be got in 5.10 and parameter is shown in Table 21.

7.12 FCS

The Frame Check Sequence field defines as 32 bits (four octets). The FCS field is calculated over all bits of the Destination Node Address, Time to Live, U/M/B, Priority, TT, TN, CS & NM, Payload (or associated parameters for CS & NM frames), not including any bits (synchronous) or octets (asynchronous or synchronous) inserted for transparency. This also does not include the Flag Sequences and the FCS field itself. The end of payload or parameter(s) fields is found by locating the closing Flag Sequence and removing the Frame Check Sequence fields. Please refer to RFC 1662 for the calculation of 32-bit FCS.

7.13 Security Considerations for SDH/SONET aggregate pipe

Due to the malicious users possibly to pass frames of some bit patterns that may lead

to SONET/SDH-layer low-transition-density synchronization problems, SDH/SONET payload scrambling is needed, when the MSR-LEP frames is inserted into the SONET/SDH Higher Order VC or its contiguous/virtual concatenation.

The operation diagram of $(x^{43} + 1)$ self-synchronous scrambler transmitter and receiver (see Figure 11a and Figure 11b are as follows. XOR is an exclusive-OR gate function. The output bits are exclusive-ored with the raw input data bit to produce the transmitted bits. The order of bit transmission within an octet is the most significant bit first. The performing scrambler and descrambler shall be required for higher order VC-n. The C2 octet coding of the high order path signal label is specified (see ITU-T Recommendation G.707) to indicate the contents of synchronous payload envelope. It is recommended that "25" (19 hex) is used to indicate MSR-LEP with $(x^{43} + 1)$ scrambling.

The scrambling/descrambling is not required for GE and 10GE aggregate pipe.

7.14 Time Fill and Transparency

The related conventions use the method defined in RFC 1662. The Flag Sequence (Binary 01111110, hexadecimal 0x7e) must be transmitted during inter-frame time fill along MSR. An octet stuffing procedure needed to be used. The control escape octet is defined as binary 01111101 (hexadecimal 0x7d), most significant bit first. After FCS computation, the transmitter examines the entire frame between the two Flag sequences. Each flag sequence and control escape octet is replaced by a two octets sequence consisting of the control escape octet followed by the original octet exclusive-or'd with hexadecimal 0x20. Receiving side must correctly process all control escape sequences. On reception, prior to FCS computation, each octet with value less than hexadecimal 0x20 is checked. If it is flagged, it is simply removed. Each control escape octet is also removed, and the following octet is exclusive-or'd with hexadecimal 0x20, unless it is the flag sequence (which aborts a frame). Escaped data is transmitted on the link as follows: 0x7e is encoded as 0x7d, 0x5e.(Flag Sequence); 0x7d is encoded as 0x7d, 0x5d (Control Escape).

8 Filter and schedule Function

MSR filtering function is a filtering and checking facility for frame NA and TTL. All frames reaching to the MSR filter Unit will be sent first to a buffer in the Node. The MSR data node will check frame TTL and NA and perform XOR function with local NA. This frame will be taken away if TTL is zero. If its NA is match, those frames reaching destination will be processed by MSR-LEP processor and not be sent to neighbor (except for multicast and broadcast frames) along the same ring. Otherwise, those mismatched frame will go to neighbor directly by schedule unit without any processing after decrementing TTL field. This is MSR filtering function.

MSR scheduling function is a set of functions used to MSR-LEP protocol processing in Tx direction. It includes Tx Schedule Unit, functions of determination of NA, TTL, TT, TN, FCS, multicast/broadcast according to types and port configuration of Tributary, a route of Layer 3 forwarding packet, requirement of control signalling or requirement of network management. The other associated MSR-LEP protocol processing is also covered.

9 Data Node insertion and Deletion

A data node can be inserted/removed online into/from the ring by using topology discovery (5.7.1) and L2PS (5.7.2 and 5.7.3) functions while other data nodes and services will be operated normally without frame loss and service loss.

10 Tributary Loopback

Once loopback function is set, a node provides local or remote data channel shortcut from Tx interface to Rx interface in Tributary.

11 TDM Circuit Emulation (TCE) over MSR

11.1. Introduction

This section provides a protocol model along MSR for TDM based bit-stream over MSR. Each station can have one or more TCEs as Tributary of MSR. TCE is operated end-to-end along MSR and is originated from the source station and terminated at the destination (station). TCE can be half-duplex point-to-point, full-duplex point-to-point or half-duplex point-to-multipoint. The two TCE channels are shown in Figure 12.

11.2 Protocol framework of TDM Circuit Emulation (TCE)

The protocol framework of TCE shown in Figure 13 involved in the underlying octet-oriented aggregate pipe is the same as that of Figure 3 and 4, and the protocol stack of Figure 14 involved in the underlying bit-oriented aggregate pipe is also almost identical to that of Figure 5 and 6. The functions of encapsulation, real-time transport of order, detection of disorder and duplication, sorting, error report, primitives and related parameters, and timing synchronous processing etc are performed within the MSR-LEP.

figure 13 shows TDM Service Channel over Octet oriented MSR-LEP

figure 14 shows The TDM Service Channel over Bit oriented MSR-LEP

11.3 Services provided by MSR Data link

11.3.1 Definitions

The layer services provided by MSR Data link to TCE layer are:

- Transfer of service data units with a constant source bit rate from TCE layer and the delivery of them with the same bit rate in MSR data link layer;
- Transfer of timing information between source and destination;
- Transfer of structure information between source and destination;
- Indication of lost or errored information which is not recovered by MSR data link if needed,.

11.3.2 Primitives between DL and the DL user

11.3.2.1 General

At the Service Access Point (SAP) of MSR DL, the following primitives is used between the MSR DL and the TCE layer:

- From a TCE layer to the MSR DL,

  DL-UNACK-DATA Request;
- From the MSR DL to the TCE layer,

  DL-UNACK-DATA Indication.
- From the MSR DL to the management entity;

  MDL-ERROR Indication.

A DL-UNACK-DATA request primitive at the local DL-SAP results in a DL-UNACK-DATA indication primitive at its peer DL-SAP.

11.3.2.2 Definition of Data Link Primitives

11.3.2.2.1 DL-UNACK-DATA request (Does not have signalling frame)

DL-UNACK-DATA request
(USERDATA [Necessary],
STRUCTURE [optional])

The DL-UNACK-DATA request primitive requests the transfer of the DL-SDU, i.e. contents of the USERDATA parameter, from the local DL entity to its peer entity. The length of the DL-SDU is constant and the time interval between two consecutive primitives is constant. These two constants are a function of the DL service provided to the TCE layer.

11.3.2.2.2 DL-UNACK-DATA indication (Does not have signalling frame)

DL-UNACK-DATA indication
(USERDATA [Necessary],
STRUCTURE [optional],
ERROR [optional])

A DL user is notified by the DL that the DL-SDU, i.e. contents of the USERDATA parameter, from its peer is available. The length of the DL-SDU should be constant and the time interval between two consecutive primitives should be constant. These two constants are a function of the DL service provided to the TCE layer. T_error, REG_lost and REG_duplicated

11.3.2.2.3 MDL-ERROR indication

MDL-ERROR indication (T_error [Necessary],
REG_lost [optional],
REG_duplicated [optional])

REG_lost and REG_duplicated parameters are used to identify how many sequence frames are lost and duplicated from the transmit side to receive side in the specific period (T_error). Once sequence lost or duplicated is occurred, MDL-ERROR indication will be applied.

11.3.2.4 Definition of Primitive Parameters

11.3.2.4.1 USERDATA parameter

The USERDATA parameter carries the DL-SDU to be sent or delivered. Its size depends on the specific DL layer service used. For the same type of TCE payload, i.e. ITU-T G.702 PDH circuit, the payload length of DL-PDU is constant and default is set to 64bytes. For the supported TCE payloads, the payload length of DL-PDUs is defined as following.

TABLE 22 – Selection of Default Payload Length of DL-PDU

Types of TCE payload	Default Payload Length of DL-PDU (bytes)
G.707 SDH circuit -- Transport of TU-11, TU-12 or TU-2	64
G.702 PDH circuit -- Synchronous circuit transport	64
G.702 PDH circuit -- Asynchronous circuit transport	64
Video signal -- Distributive television services	188
Video signal -- Conversational services of bit rates higher than primary rates	188
Video signal -- Conversational services of p×64 kbit/s	188

signals	
Voiceband signal -- 64 kbit/s A-law or μ-law coded Recommendation G.711 signals	64
Digital channel supported by 64 kbit/s-based ISDN -- Transport of 64 kbit/s channel	64
Digital channel supported by 64 kbit/s-based ISDN -- Transport of 384, 1536 or 1920 kbit/s channel	64
Note: the above default values can be changed by configuration according to the alignment rule of 4-octet based DL PDU structure and 64kbit/s rate.	

11.3.2.4.2 STRUCTURED parameter (option of DL-UNACK-DATA Primitive)

The STRUCTURED parameter can be used when the data stream of TCE layer to be transferred to the peer DL entity is organized into groups of bits. The length of the structured block is fixed for each instance of the DL service. The length is an integer multiple of 8 bits. An example of the use of this parameter is to support circuit mode bearer services of the 64 kbit/s-based ISDN. The two values of the STRUCTURED parameter are:

BOUND and

DATA-STREAM.

The value BOUND is used when the USERDATA is the first part of a structured block which can be composed of consecutive USERDATA. In other cases, the structure parameter is set to DATA-STREAM. The use of the STRUCTURED parameter depends on the type of DL service provided. The use of this parameter is agreed prior to or at the connection establishment by network management between the TCE layer and the Data Link layer.

11.3.2.4.3 ERROR parameter (option of DL-UNACK-DATA Primitive)

The ERROR parameter identifies that the USERDATA is judged to be non-errored or errored. The ERROR parameter has two values:

NO and

YES.

The "YES" value does imply that the USERDATA is a dummy value. The use of the ERROR parameter and the choice of dummy value depend on the type of DL service provided. The use of this parameter is agreed prior to or at the connection establishment between the TCE layer and the DL layer.

11.3.2.4.4 T_error, REG_lost and REG_duplicated parameters

The connection management entity is used to monitor the error status of receiving the peer link frame. It is local matter only and has not any associated frame to be used between the two sides.

REG_lost and REG_duplicated parameters are attached to MDL-ERROR Indication primitive to identify how many sequence frames are lost and duplicated from the transmit side to receive side in the specific period (T_error). Their values is stored to two specific registers in the receive side. The parameter T_error in the unit of second is an initial value and configurable by the network management according to the rate of specific service over DL. At the beginning of MSR Data Node start-up, the REG_lost and REG_duplicated are set to zero.

--If the timer T_error expires before any lost or duplicated frames are received, the link entity shall restart timer T_error. The DL entity shall not indicate this to the local connection management entity.

--Once the timer T_error expires and any lost or duplicated frame is received, the DL entity shall indicate this to the local connection management entity by means of the MDL-ERROR indication primitive, and restart timer T_error.

11.4 Supported Functions of MSR DL for TCE case

The following functions can be performed in the MSR DL in order to meet requirements of TDM timing, structure, jitter and wander:

a) source clock frequency recovery at the receiver;

b) recovery of the source data structure at the receiver;

c) blocking and deblocking of DL user information;

d) control of frame latency variation;

e) processing of lost or duplicated frames;

NOTE – For some DL users, the end-to-end QOS may be monitored. This may be achieved by calculating a CRC for the DL-PDU, A corresponding periodic account of CRC computation is sent to element management system. Further study is required.

11.4.1 TCE processing mode along MSR

11.4.1.1Processing mode of G.707 SDH

This sub-section presents the processing mode of G.707 SDH signals along MSR. Care should be taken to select the shortest transport path, control priority of delivery and transient, and reduce transport latency and latency variation along MSR during the project installation phase.

1) Mode of TU-11, TU-12 or TU-2

a) Circuit rate at DL service boundary: 1728; 2304 or 6912 kbit/s

b) Source clock frequency recovery: Synchronous timing

c) Error status indication at the receiver: count report of lost or duplicated frames by MDL-ERROR Indication primitive.

11.4.1.2Processing mode of G.702 PDH

For this sub-section, it is necessary to identify TCE data structure and the clock operation mode at the DL service boundary, i.e. framing or non-framing, types of clock (synchronous or asynchronous) where needed to make comparison to a network clock. Asynchronous and synchronous TCE transport provides transport of signals from TCE sources whose clocks are non-frequency-locked and frequency-locked to a network clock respectively. The judgement of synchronous or asynchronous will depend on the service provided by the specific network, i.e. PDH, SDH, or ISDN.

Care should be taken to select the shortest transport path, control priority of delivery and transient, and reduce transport latency and latency variation along MSR during the project installation phase.

1) Asynchronous G.702 circuit

- Circuit rate at DL service boundary: 1.544, 2.048, 6.312, 8.448, 44.736 and 34.368 Mbit/s as specified in Recommendation G.702.
- Source clock frequency recovery: Asynchronous frequency
- Error status indication at the receiver: count report of lost or duplicated frames by MDL-ERROR Indication primitive.

2) Synchronous G.702 circuit

- Circuit rate at DL service boundary: 1.544, 2.048, 6.312, 8.448, 44.736 and 34.368 Mbit/s as specified in Recommendation G.702.
- Source clock frequency recovery: Synchronous timing
- Error status indication at the receiver: count report of lost or duplicated frames by MDL-ERROR Indication primitive.

11.4.1.3Processing mode of Video signal transport

This sub-section presents the processing mode of Video signal transport. Care should be taken to select the shortest transport path, control priority of delivery and transient, and reduce transport latency and latency variation along MSR during the project installation phase.

1) Mode of Conversational services of p×64 kbit/s signals

This sub-section gives the processing mode of interactive video signals of the p × 64 videotelephony and videoconference applications as specified in Recommendation H.320.

a) Circuit rate at DL service boundary: 384, 1536 or 1920 kbit/s in the 64 kbit/s-based ISDN by using H0, H11, H12, respectively.

b) Source clock frequency recovery: Synchronous timing

c) Error status indication at the receiver: count report of lost or duplicated frames by MDL-ERROR Indication primitive.

2) Mode of Distributive television services

This sub-section illustrates transport of distributive television signals encoded by using MPEG2 with a constant bit rate specified in Recommendation J.82.

a) Circuit rate at DL service boundary: Depending on MPEG2 parameters

b) Source clock frequency recovery: Asynchronous frequency

c) Error status indication at the receiver: count report of lost or duplicated frames by MDL-ERROR Indication primitive.

3) Mode of Conversational services of bit rates higher than primary rates

This sub-section illustrates transport of interactive video signals for, i.e. video-telephony and conference application specified in Recommendation H.310.

a) Circuit rate at DL service boundary: Depending on H.310 parameters

b) Source clock frequency recovery: Synchronous/Asynchronous per Recommendation H.310

c) Error status indication at the receiver: count report of lost or duplicated frames by MDL-ERROR Indication primitive. Recommendation H.310 should be taken into account.

11.4.1.4Processing mode of digital channel supported by 64 kbit/s-based ISDN

This sub-section presents the processing mode of digital channel supported by 64 kbit/s-based ISDN. Care should be taken to select the shortest transport path, control

priority of delivery and transient, and reduce transport latency and latency variation along MSR during the project installation phase.

1) Mode of 64 kbit/s channel

a) Circuit rate at DL service boundary: 64 kbit/s

b) Source clock frequency recovery: Synchronous timing

c) Error status indication at the receiver: count report of lost or duplicated frames by MDL-ERROR Indication primitive.

2) Mode of 384, 1536 or 1920 kbit/s channel

a) Circuit rate at DL service boundary: 384, 1536 or 1920 kbit/s

b) Source clock frequency recovery: Synchronous timing

c) Error status indication at the receiver: count report of lost or duplicated frames by MDL-ERROR Indication primitive.

11.4.1.5Processing mode of Voice-band signal

This sub-section presents the processing mode of 64 kbit/s A-law or μ-law coded Recommendation G.711 signals. Care should be taken to select the shortest transport path, control priority of delivery and transient, and reduce transport latency and latency variation along MSR during the project installation phase.

a) Circuit rate at DL service boundary: 64 kbit/s

b) Source clock frequency recovery: Synchronous timing

c) Error status indication at the receiver: count report of lost or duplicated frames by MDL-ERROR Indication primitive.

11.4.2 TCE Function of MSR Data Link

11.4.2.1 TCE Functions for circuit

The following sections provide both asynchronous and synchronous TCE transport function along MSR. Asynchronous and synchronous TCE supports transport of

signals from constant bit rate sources whose clocks are non-frequency-locked and frequency- locked respectively to a network clock. Asynchronous examples are Recommendation G.702 signals at 1.544, 2.048, 6.312, 8.448, 32.064, 44.736 and 34.368 Mbit/s, Synchronous examples at 64, 384, 1536 and 1920 kbit/s as specified in Recommendation I.231 and those rates described in Recommendation G.707.

1) Consideration of DL user information

The length of the DL-SDU is 64 octets. A DL-SDU constitutes one DL PDU payload.

For those DL users that require a peer-to-peer presetting of structured data, i.e. 8 kHz structured data for circuit mode bearer services of the 64 kbit/s-based ISDN.

2) Processing strategy of frame delay variation

A buffer mechanism is used to support this function. In the event of buffer underflow, it can be necessary for the DL to maintain bit count integrity by inserting the appropriate number of dummy bits. In the event of buffer overflow, it may be necessary for the DL to maintain bit count integrity by dropping the appropriate number of bits.

When Recommendation G.702 1.544-Mbit/s and 2.048-Mbit/s signals are being transported, the inserted dummy bits shall be all "1"s.

3) Processing strategy of lost and duplicated frames

A destination DL can determine whether the frames have been lost by tracking the sequence count values of the received DL PDUs. Detected duplicated frames are discarded. The DL procedure to be used for sequence count processing is described in 11.5.2.

In order to maintain the bit count integrity of the DL user information, it may be necessary to compensate for lost frames detected by buffer underflow and sequence count processing by inserting the appropriate number of dummy payloads. The content of this dummy payload depends

on the DL service being provided. For example, this dummy payload is all "1"s for Recommendation G.702 1.544 Mbit/s and 2.048-Mbit/s signals.

4) Guaranty of jitter and wander

This function is required for delivery of DL-SDUs to a DL user at a constant bit rate. Recovered source clock should meet the requirement of jitter and wander performance. For example, the jitter and wander performance for Recommendation G.702 signals is specified in Recommendations G.823 and G.824, for which the DL procedure to be used.

11.4.2.2 TCE Functions of video signal

The following sections present processing of video signals for interactive and distributive services:

1) Consideration of DL user information

The length of the DL-SDU is 188 octets. A DL-SDU constitutes one DL PDU payload.

For those DL users that require a peer-to-peer presetting of structured data. Depending on the type of DL service provided (i.e. the interface to the DL user), the ERROR parameter will be passed to the DL user to facilitate further picture processing.

2) Processing strategy of frame delay variation

A buffer mechanism is used to support this function. The size of this buffer is dependent upon specifications video signal. In the event of buffer underflow, it may be necessary for the DL to maintain bit count integrity by inserting the appropriate number of dummy bits. In the event of buffer overflow, it may be necessary for the DL to maintain bit count integrity by dropping the appropriate number of bits.

3) Processing of lost and duplicated frames

A destination DL can determine whether the frame has been lost by tracking the sequence count values of the received DL PDUs. Detected duplicated frames are discarded. The DL procedure to be used for sequence count processing is described in 11.5.2.

In order to maintain the bit count integrity of the DL user information, it may be necessary to compensate for lost frames detected by buffer underflow and sequence count processing by inserting the appropriate number of dummy payloads. The content of this dummy payload depends on the DL service being provided.

Information in lost frames may be recovered by the mechanism described in e).

4) Guaranty of jitter and wander

This function is required for delivery of DL-SDUs to a DL user at a constant bit rate.

Some DL users may require source clock frequency recovery, i.e. recovery in the receive side of camera clock frequency that is not locked to the network clock. The DL procedures available for that purpose are given in 11.5.2.

11.4.2.3 TCE Functions of voice-band signal

The following sections support processing of a single voice-band signal, i.e. one 64 kbit/s A-law or -law coded Recommendation G.711 signal.

1) Consideration of DL user information

The length of the DL-SDU is 64 octets. A DL-SDU constitutes one DL PDU payload.

2) Processing of frame delay variation

A buffer mechanism is used to support this function. The size of this buffer depends on specifications provided in voice-band signal.

3) Processing strategy of lost and duplicated frames

For voice-band signals, there is a need still to detect duplicated and lost frames.

The receiving DL entity must detect/compensate for lost frame events to maintain bit count integrity and must also minimize the delay, i.e. to alleviate echo performance problems, in conveying the individual voice-band signal octets from the DL-PDU payload to the DL user. The receiving DL entity may take actions based on the received Sequence Number values, but such actions must not increase the conveyance delay across the DL receiving entity to alleviate echo performance problems.

The DL receiving entity must accommodate a sudden increase or decrease in the nominal frame transfer delay. (A protection switching event in the MSR may result in a change of transfer delay.)

4) Guaranty of jitter and wander

The DL provides synchronous circuit transport for the voice-band signal.

NOTE 1 – Example receiver techniques using a timing-based mechanism or a buffer-fill-based mechanism, possibly supplemented by a Sequence Number processing algorithm that does not introduce additional delay.

NOTE 2 – For transporting signals of speech and 3.1 kHz audio bearer services as specified in 64 kbit/s ISDN, the need for A/ -law conversion is identified. The conversion between A-law and -law coded PCM octets are as specified in Recommendation G.711. This conversion function is outside the scope of this Patent.

11.4.2.4 TCE Functions of high quality audio signal

The case is the same as the above. The TCE functions of high quality audio signals in DL include the following capabilities in principle.

a) Consideration of DL user information;

b) Processing strategy of frame delay variation;

c) Processing of lost and duplicated frames;

d) Guaranty of jitter and wander;

11.5 DL protocol involved to support TCE

The following sub-sections describe DL procedures to be provided for implementing DL functions involved to support TCE.

11.5.1 Processing strategy of sequence number

11.5.1.1Processing in the transmit side

The DL provides a sequence count value and a DL indication associated with each DL-PDU payload in the transmit side. The count value applied to FSN field starts with 0, is incremented sequentially to 255 and is numbered modulo 256 when TT field is set to support TCE function. When the data link frames carrying TCE payloads traverse a MSR, then may arrive destination station disorderly. Due to this reason, it is required that frames must be delivered in order. Ensuring in-order delivery is also effective approach to out-of-order detection.

11.5.1.2Processing in the receive side

The DL receives and derives the following information associated with each DL-PDU payload in receive side:

- sequence number;
- count;
- check error of the sequence number and count.

The implementation of sequence count values and number will be specified on a service specific basis. The DL entity in the receive side identifies lost or duplicated DL-PDU payloads.

DL entity tracks the following status of dynamic data stream:

- DL-PDU payload sequence number and count;
- DL-PDU payload loss (if occur);
- DL-PDU payload duplication (if occur).

There are two ways to solve the real-time processing problem, (1) try to reorder and sort into the correct order or (2) drop those disordering frames, when disordering case occurred. In implementation, These two methods should be all supported. If method (1) does not meet reliability transport and performance requirement still, the method (2) will be applied. Due to the limitation of native speed and acceptable delay of data link payloads listed in Table 22, this Patent does not support correction method for bit errors and frame losses.

11.5.2 Recovery method of timing and structured information

To support TCE services available in Table 22, the requirements of timing and structured information should be based on the native characteristics of the these services, and it is necessary for these TCE to recover these signal characteristics as closely specified in the related standard as possible in the receive side, including the signal jitter, bit-rate, timing characteristics and structured information transfer (if it has) as it was sent. There are two methods involved: timing (synchronous) signalling broadcasted periodically from that designated station with an external synchronous source along the MSR ring, or timing (synchronous) information received from an external facility for referencing to all stations along the MSR.

SYNCHRONIZATION Request (Local NA, T_sync)

The signalling frame of broadcast SYNCHRONIZATION Request primitive has the highest priority among all other signalling frame defined in this Patent. The broadcasted period is Timer T_sync. Its default value is 8000 frames per second. This value is programmable and can be changed by network management attached to MSR.

SYNCHRONIZATION Confirm (Non parameter)

After getting the signalling frame of SYNCHRONIZATION Request, said each

station will align the phase relations of its oscillator facility (including frequency-locked) and send SYNCHRONIZATION Confirm signalling frame with lower priority to that source station initiated the signalling frame of SYNCHRONIZATION Request. The codes of these two signalling are listed in the Table 5.

Since the service types and connection relations of TCEs from source to destination along MSR, including Node address, TT and TN, are pre-plan, said initial timing (except for phase relations and actual bit-stream) and structured information should be pre-set by configuration function of network management attached to MSR via management interface before operation of those TCE services. The phase relations and actual bit-stream of TCE signals are designed to perform the extraction of output transmission bit timing information from the delivered frame stream, and requires a phase-locking mechanism.

11.6 Management function involved to support TCE

The following functions is required to be provided to the management interface:

11.6.1 TCE property (including structured information of data stream) mismatch between the source and destination along MSR

A TCE should be set up by means of

CONNECTION_Request frame (Destination NA, Destination TT, Destination TN, Source NA, Source TT, Source TN).

Before a peer-to-peer emulated connection can be established. After getting CONNECTION_Request management frame, the remote peer entity will compare properties of both side, perform the associated action and give

CONNECTION_Confirm frame (Destination NA, Destination TT, Destination TN, Source NA, Source TT, Source TN).

When a peer-to-peer emulated connection is no longer provided. TCE connection must be terminated using

DISCONNECTION_Request frame (Destination NA, Destination TT, Destination TN, Source NA, Source TT, Source TN)

Once getting DISCONNECTION_Request frame, the remote peer entity will perform the associated action and issue

DISCONNECTION_Confirm frame (Destination NA, Destination TT, Destination TN, Source NA, Source TT, Source TN).

11.6.2 Errors in the TCEs transmission

11.6.3 Lost or duplicateded frames

11.6.4 Synchronization loss

11.6.5 Buffer underflow and overflow

12 Tributary Based Protection (TBP)

The said Tributary of this section is a logical service channel defined in 3.41, such as Ethernet/GE and TCE etc with a fixed value of Tributary Type (TT) and Tributary Number (TN) in the MSR frame. The Tributary based protection is located at full-duplex point-to-point application only. The Tributary protection operation of half-duplex point-to-point, multicast and broadcast will not be the scope of this section. A Node of MSR can provide support of multiple ETBP and Multiple TTBP at the same time.

12.1 Ethernet Tributary Based Protection (ETBP)

In the case of non-TBP, IPG (Inter Packet Gap) is not used to map into payload of SDH/SONET/GE/10GE, just like X.86/Y.1323 (Ethernet over LAPS) transmits Ethernet traffic in order to save line bandwidth. But once a Ethernet or Gigabit Ethernet Tributary is set to support TBP by network management, transmitting and

mapping IPG messages in the Ethernet or GE are basic function and are required to provide to MSR. When needed to support the ETBP Function, ETBP Function Unit embedded in the corresponding Tributary in DL entity will be activated by the configuration of network management (this configuration is performed either in the projection installation phase or MSR on-line operation phase) and the corresponding Tributary is set to a Working Tributary.

For Operation of 1+1 ETBP, it is needed to designate a mate Standby Tributary with the same service property, source and destination. The payloads of said mate Working Tributary and Standby Tributary will carry the same traffic.

For 1:1 ETBP, it is also needed to designate a mate Standby Tributary with the same service property, source and destination. The payloads of said Standby Tributary can carry the other additional traffic (Once ETBP occurred for this Working Tributary, the additional traffic will be taken away).

For 1:N ETBP, there are N Working Tributaries, it is also needed to designate a mate Standby Tributary with the same service property, source and destination. The payloads of said Standby Tributary can carry the other additional traffic (Once ETBP in one of N Working Tributary occurred, this additional traffic will be taken away).

The ETBP Function Unit is used to monitor the link status of receiving the peer link frames. It is local matter only and has not any associated frame to be used between the two sides.

--After initialization (the defaults of T_etbp and N_etbp are set to 10 mill-seconds and 4 respectively), the link entity enters the normal way of transmitter and receiver.

--If the timer T_etbp expires before any frame (including information frame and IPG) is received, the link entity shall restart timer T_etbp and decrement the retransmission counter N_etbp.

--If the timer T_etbp expires and retransmission counter N_etbp has been decremented to zero before any frame (including information frame and IPG) is received, the link entity shall perform an action of ETBP (1+1, 1:1 or 1:N) to the corresponding Standby Tributary, send a L2PS_Request primitive (that is

L2PS_Request signalling frame to transmitting end of the corresponding Working Tributary) with the TT and TN parameters and indicate a notification to the local ETBP Function Unit by means of the L2PS_EVENT_Report primitive with the TT and TN parameters (that is L2PS_EVENT_Report signalling frame to Management entity), then restart timer T_etbp and recover the value of N_etbp.

--For the case of 1:1 and 1:N, after the ETBP Function Unit receives L2PS_Request signalling frame with the TT and TSN parameters, the link entity in the transmit side will perform an action of ETBP (1:1 or 1:N) to the corresponding Standby Tributary.

--The value of T_etbp and N_etbp shall be configurable. The minimum unit configured of T_etbp and N_etbp is 1 milliseconds and 1 respectively.

Once ETBP Function Unit detects that the receive side of Working Tributary is recovered and enters normal status from the ETBP, ETBP Function Unit will wait T_etbp_wtr (The default to 10 minutes, its value is also programmable and should be much greater than T_etbp), and then switch to the Working Tributary. After switching to the Working Tributary, ETBP Function Unit issues a L2PS_RECOVERY_EVENT_Report with parameters of TT and TN to management entity.

12.2 TCE Tributary Based Protection (TTBP)

When needed to support the TTBP function, TTBP Function Unit embedded in the corresponding Tributary in DL entity will be activated by the configuration of network management (this configuration is performed either in the projection installation phase or MSR on-line operation phase) and the corresponding Tributary is set to a Working Tributary.

For Operation of 1+1 TTBP, it is needed to designate a mate Standby Tributary with the same service property, source and destination. The payloads of said mate Working Tributary and Standby Tributary will carry the same traffic.

For 1:1 TTBP, it is also needed to designate a mate Standby Tributary with the same

service property, source and destination. The payloads of said Standby Tributary can carry the other additional traffic (Once TTBP occurred for this Working Tributary, the additional traffic will be taken away).

For 1:N TTBP, there are N Working Tributaries, it is also needed to designate a mate Standby Tributary with the same service property, source and destination. The payloads of said Standby Tributary can carry the other additional traffic (Once TTBP in one of N Working Tributary occurred, this additional traffic will be taken away).

The TTBP Function Unit is used to monitor the link status of receiving the peer link frames. It is local matter only and has not any associated frame to be used between the two sides.

--After initialization (the defaults of T_ttbp and N_ttbp are set to 10 mill-seconds and 4 respectively), the link entity enters the normal way of transmitter and receiver.

--If the timer T_ttbp expires before any frame is received, the link entity shall restart timer T_ttbp and decrement the retransmission counter N_ttbp.

--If the timer T_ttbp expires and retransmission counter N_ttbp has been decremented to zero before any frame is received, the link entity shall perform an action of TTBP (1+1, 1:1 or 1:N) to the corresponding Standby Tributary, send a L2PS_Request primitive (that is L2PS_Request signalling frame to transmitting end of the corresponding Working Tributary) with the TT and TN parameters and indicate a notification to the local TTBP Function Unit by means of the L2PS EVENT_Report primitive (that is L2PS_EVENT_Report signalling frame to Management entity), then restart timer T_ttbp and recover the value of N_ttbp.

--For the case of 1:1 and 1:N, after the TTBP Function Unit receives L2PS_Request signalling frame, the link entity in the transmit side will perform an action of TTBP (1:1 or 1:N) to the corresponding Standby Tributary.

--The value of T_ttbp and N_ttbp shall be configurable. The minimum unit configured of T_ttbp and N_ttbp is 1 milliseconds and 1 respectively.

Once TTBP Function Unit detects that the receive side of Working Tributary is recovered and enters normal status from the TTBP, TTBP Function Unit will wait T_ttbp_wtr (The default to 10 minutes, its value is also programmable and should be much greater than T_ttbp), and then switch to the Working Tributary. After switching to the Working Tributary, TTBP Function Unit issues a L2PS_RECOVERY_EVENT_Report with parameters of TT and TN to management entity.

13 Tributary Based Multicast (TBM)

The said Tributary of this section is a logical service channel defined in 3.41, such as Ethernet/GE and TCE etc with a fixed value of Tributary Type (TT) and Tributary Number (TN) in the MSR frame. The Tributary Based Multicast (TBM) is located at the operation of half-duplex point-to-multi-point application only. The full-duplex point-to-point will not be recommended to the scope of this section. A Node of MSR can provide support of one or more independent hierarch of multicast possibly involved the same or different TT at the same time.

The TBM Function Unit built in a MSR Node is defined to support one or more independent hierarch of multicast possibly involved the same or different TT at the same time. TBM Function Unit implements a duplication function within a Node (station) from a Tributary getting a payload of DL frame to other multiple Tributary with the same TT value and with being set to have a relation of membership group. A group of TN with the same TT value within a Node can be set to become a membership group. It is required that a designated Tributary in the membership group should receive data frames at the reference point T1 from a MSR ring. This Patent defines this designated Tributary as a Source Tributary (ST). Once getting data frames, the ST duplicates those frames to every Tributary in the corresponding membership group. The ST should be set and designated to a given value of TT and TN by network management during the project installation phase or on-line operation phase.

The one or more STs can be designated or changed dynamically within a Node according to the customer requirement.

If a TBP is applied to operation of TBM, it is recommended that a ST be designated to a Working Tributary for the 1+1 and 1:1 application in the normal case.

14 Bandwidth Limitation, Bundle, Line-Speed Filtering, Stacking and Mirroring of Tributary

14.1 Bandwidth Limitation of Tributary Based

Ethernet/GE and TCE rate at DL service boundary should be operated and be fully compliant with the IEEE 802.3, G.702, G.707, ISDN and other related standards in the normal case. But in some application of service level agreement, the policy of operation and maintenance needs a limitation for rate to perform the bandwidth-based accounting. The MSR entity provides a Bandwidth Limitation Function Unit. When this Function Unit is activated to a Trbutary, this Tributary provides configuration incremental level with minimum unit granularity (1Mbit/s for Ethernet, 10Mbit/s for GE and 64Kbit/s for TCE) from 0 to the maximum value. The corresponding maximum values of bandwidth are specified in the related standard and must not be passed over. Once bandwidth is set up for a Tributary during project installation or operation phase, this programmable threshold limit applies to this Tributary and its corresponding port. The setting of bandwidth threshold and monitoring of actual traffic flow are performed by configuration function and management entity.

Bandwidth Limitation of Tributary Based can be used to operations of half duplex point-to-point, full duplex point-to-point, multicast and broadcast.

14.2 Tributary Bundle

The MSR entity provides a Bundle Function Unit by which up to sixteen Tributarys of the same TT can be bundled together to form a Tributary Bundle Group (TBG). Up to eight TBGs can be established in a MSR node. The TBG is similar to one logical link and is very useful when higher bandwidth of application is required. The member

Tributary of a TBG must be of the same TT and configured in full-duplex mode. The benefits of forming a TBG are link redundancy, aggregate throughput, incremental bandwidth, load balancing on the TBGs. Once a TBG is formed, a TBG of either Ethernet/GE or TCE must be identified using only a TN value (e.g. the first member Tributary) in the corresponding frames of data, signalling and network management. For upper layer application over a TBG, a logical channel can only be seen externally.

14.3 Line-Speed Filtering of Tributary Based

The MSR entity provides a Line-Speed Filtering Function Unit (LSFFU) to Content-Aware frame classification, which enables a node processing application to filter and classify frames based on certain protocol fields of upper layer in the payload of frame. Filters can be set on defined fields from Layer 2 to Layer 7 within a frame. LSFFU of a MSR node can filter individual ingress or egress ports of Tributary. Filtering algorithm uses two constructs, (a) the filter mask, which defines which fields to filter, and (b) the rules table, which defines the filtering options. Up to 48 filters are available, each containing a 64-byte wide shuttered filter mask value to apply on any protocol field at any offset within the first 96 bytes of the incoming frame. The rules table is up to 256 entries deep for 10/100-Mbit Ethernet and TCE Tributary, and 128 entries deep for 1000-Mbit Tributary.

Once the classification results and filter match or partial match have been gotten, the following policies can be taken, in any combination:

• Modification of the IP Type Of Service (TOS precedence) field

• Delivery of a copy of the related frames to the domain of management by CPU

• Discarding the related frames

• Transferring the related frames to other egress port

• Transmission of a copy of the related frames to the "mirrored to" Tributary

• Modification of protocol field, e.g. inserting a 802.1p tag for Ethernet application

The LSFFU provides the ability to track and profile up to 1024 data flows. The traffic

on these data flows can be monitored or regulated via internal meters and has the ability to assign two independent policies to the profile status of a data flow and execute these actions at line rate.

14.4 Mirroring of Tributary

Tributary Mirroring Function Unit (TMFU) facilitates monitoring the incoming or outgoing traffic on a related Tributary by connecting a sniffer to a "mirrored to" Tribuatry. The TMFU provides mirroring function of any Tributary if needed. The Tributary being mirrored is referred as "mirrored-to Tributary". Any Tributary can be used as the mirrored to Tributary. Both the received and transmitted frames on the mirrored Tributary can be sent to the mirrored-to port. The type of traffic that gets mirrored is programmable. A set of dataflow sent to the "mirrored-to" Tributary can be configured by setting specified rules, such as:

• Delivery to egress only—the related frames sending to a particular Tributary within a node.

• Delivery to ingress only—the related frames receiving from a particular Tributary.

• Delivery to both egress and ingress—the related frames both sending to and receiving from a particular Tributary within a node.

15 Topology Application of Single Fibre Ring, Link-type and Broadcast Network

15.1 Support of a single fibre ring

MSR is defined for a default application on a bi-directional symmetric counter-rotating two fibre optical rings. In some case, due to the limitation of fibre resource in which two fibres are available to a ring, it is recommended that a single fibre ring shown in the Figure 15 be applied. If the topology is involved in Figure 15, the L2PS of Aggregate Pipe based, data node insertion and deletion should not be used. Instead, these functions will be switched off via configuration function of the network management.

15.2 Support of a Link-type with Adding and Dropping Tributary Services

In some application, it is needed to build a link-type topology shown in the Figure 16 in which the connection between Node 2 and Node 4 is one or more Tributaries. This Tributary may be an aggregate pipe of other MSR span with a lower rate than that of this aggregate pipe. If the topology is involved in Figure 16, the L2PS of Aggregate Pipe based, data node insertion and deletion should not be used. Instead, these functions will be switched off via configuration function of the network management.

15.3 Support of a Broadcast Connection to DVB Application

In DVB application, it is needed to build a broadcast network topology shown in the Figure 17 in which the connections from Node 1 to Node2/Node3/Node 4 are aggregate pipes of single direction. If the topology is involved in Figure 17, the L2PS of aggregate pipe based, data node insertion and deletion, Tributary based Protection and in-band network management should not be used. Instead, these functions will be switched off via configuration function of the network management.

15.4 Support of a Pseudo-mesh Topology

Pseudo-mesh Topology presented in Figure 18 is a particular example of MSR ring. Eight Nodes via aggregate pipe are attached together to form a MSR ring. This Tributary may be an aggregate pipe of other MSR span with a lower rate than that of this aggregate pipe. The Tributaries of Node 2, 4, 6 and 8 are connected to the Node 9. In this application, all function and specifications defined in the Patent can be used effectively.

16 Implementation example

The MSR Data Node Machine (MDNM) provides a wide range of choices in levels of manageability and solution costs. Comparison between RPR (Resilient Packet Ring) and MSR is made as following:

(1) RPR is a router-based ring including Fairness algorithm, Dynamic Node Insertion

and Deletion, Automatic Topology Discovery. MSR is a link and frame encapsulation protocol to perform transparent transferring of various tributary services. IP packet is also treated as a kind of tributary service and it may be processed in the way of Layer 3 forwarding with the lower priority.

(2) RPR does not have tributary number for the same service. MSR can support the transferring of up to 2048 same type services and independent channels, e.g. 10/100 Ethernet or DVB (MPEG2) over SDH/GE along a ring, just like X.86 application in a ring.

(3) RPR can implement node-based broadcast between different nodes. MSR can provide both service channel based broadcast in a single node and node-based broadcast between different nodes, e.g. 2048 10/100Mb/s Ethernet or MPEG2 channels can receive same broadcast services in a single node.

(4) PPPoE and PPPoA used to customer access are transferred in transparent way in MSR node along a ring. The advantage of doing this, is that accounting mechanism (e.g. Radius) is simplified, maintenance work is reduced and latency variance (compared to Layer 2 and Layer 3 switch) is improved in MAN.

(5) MSR can implement both Tributary based protection within 50ms and aggregate based protection. RPR could only support aggregate based protection.

(6) MSR can be applicable to ring of single-fiber, two-fiber and four-fiber. MSR also can be applicable to line and T type topologies by configuration.

(7) A aggregate span can use SDH/SONET, and other span use GE/10GE in the same MSR ring.

(8) MSR uses local link address, does not have issue of MAC address assignment.

(9) MSR does not support VLAN and MAC Bridge. It uses directly back-to-back physical connection between two MSR rings.

(10) MSR transfers various service tributaries and establishes channels relationship including priority and bandwidth assignment by using configuration of project installation, so MSR does not use Fairness algorithm.

(11) A Low rate MSR can be operated as a Tributary of a High Speed MSR

(12) The service tributary interfaces of MSR can support Ethernet, TDM Circuit

Emulation (including the emulation of G.707 SDH circuit -- Transport of TU-11, TU-12 or TU-2, G.702 PDH circuit -- Synchronous and asynchronous circuit transport, Video signal, Voiceband signal, Digital channel supported by 64 kbit/s-based ISDN) and other MSR Tributary with a lower rate of aggregate pipe. MSR data node supports node based protection, tributary based 1+1, 1:1 and 1:N protection, tributary based multicast, tributary bandwidth Limitation, tributary bundle, tributary Line-Speed Filtering, tributary Mirroring.

The hardware architecture presented in Figure 19 is a typical example of MSR node. The Aggregate Processor board is responsible for transmitting, receiving and processing of Aggregate Pipe traffic, signalling operation of Routing Engine for Ipv4/Ipv6, ICMPv4/v6, IGMPv4/v6, TCP/UDP, RIPv1/v2, OSPFv2,IS-IS, BGP, L3 Packet Forwarding operation, operation of Network Management for SNMP and its MIB. The Tributary adaptation & processing board is in charge of Tx framer, Rx framer, adaptation and conversion of various Tributaries. Internal CS & NM bus (e.g. 10/100Mbit/s Ethernet bus or IEEE 488 bus) is used to communication of internal circuit boards. The layout of a MSR node shelf is also shown in the Figure 20. The aggregate processor board located in the middle of the shelf can be used to build 1+1 dual-board structure, connected to two-fibre of both east side and west side. Other circuit board provides various Tributary interfaces, and related adaptation and processing.

Annex A

Ethernet data processing in the case of SDH/SONET based Aggregate Pipe

The MSR-LEP processing is divided into transmit and receive processing as follows:

A.1 The MSR-LEP Transmit Processing

1) Receive MAC frame through MII or GMII from MAC and detect the SPD (Start Frame Delimiter);
2) Synchronize it to the SDH clock;
3) Add start flag (0x7e) of MSR-LEP frame;
4) Add destination NA, Time-to-Live, U/M/B, FWR/SWR, Priority, TT and TN fields to the MSR-LEP frame;
5) FCS generation over destination NA, Time-to-Live, U/M/B, FWR/SWR, Priority, TT, TN and payload fields to the MSR-LEP frame, it does not include the Flag, Inter-frame gap and Abort sequence (0x7d7e, option) octets;
6) Transparency processing or octet stuffing within the MSR-LEP frame:

- 0x7e ≥ 0x7d, 0x5e;
- 0x7d ≥ 0x7d, 0x5d;

Octet stuffing does not occur during the transfer of Abort sequenceand Flag;

7) Add end flag (0x7e) of MSR-LEP frame;
8) Add IPG (Inter-Frame-Gap) fill octet(s) (0x7e), if needed;
9) Scramble all octets before send to SDH payload.

A.2 The MSR-LEP Receive Processing

1) De-scramble all octets before processing;
2) Remove IPG (Inter-Frame-Gap) fill octet(s) (0x7e) if needed;
3) Detect start flag (0x7e) of MSR-LEP Frame;

4) Perform octet removal (transparency processing), within the MSR-LEP Frame:

- 0x7d, 0x5e ≥ 0x7e;
- 0x7d, 0x5d ≥ 0x7d;

5) Check for validation of the destination NA, Time-to-Live, U/M/B, FWR/SWR, Priority, TT and TN fields;

6) Perform the FCS generation and checking;

7) Detect closing flag (0x7e);

8) Synchronize the MAC frame to MII RX_CLK;

9) Add preamble and SPD (Start Frame Delimiter) and send it to MAC through MII or GMII.

A.3 Erroneous Frame Handling

The MII or GMII Interface provides a method by which the MAC device could indicate to the MSR-LEP entity by TX_ERR when a particular frame contains errors and should be aborted or discarded.

The Ethernet over SDH/SONET using MSR-LEP supports two options for aborting an erroneous frame.

The first option is to abort a frame by inserting the abort sequence, 0x7d7e. Reception of this code at the far end will cause the receiver to discard this frame (the Abort sequence octets are also scrambled).

For the second option, the MSR-LEP entity can also abort an erroneous frame by simply inverting the FCS octets to generate an FCS error. The selection of abort mode is controlled via the management interface.

An invalid frame is a frame which:

a) is not properly bounded by two flags; or

b) has fewer than sixteen octets between flags of frames; or

c) contains a FCS error; or

d) contains a NA, U/M/B, TT or TN which are mismatched or not supported by the receiver.

e) has an invalid control sequence.

Invalid frames shall be discarded without notification to the sender. No action is taken as the result of that frame.

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ANNEX B

MSR-LEP vs. RPR

Compared to RPR, MSR-LEP is another different solution. Major differences between MSR and RPR are shown in following table.

Table B.1 – Major Feature differences

Feature	This patent	Draft P802.17
Overview	A link and frame encapsulation protocol to perform transparent transferring of various tributary services. IP packet is also treated as a kind of tributary service and it may be processed in the way of Layer 3 forwarding with the lower priority.	A router-based ring including Fairness algorithm, Dynamic Node Insertion and Deletion, Automatic Topology Discovery.
Tributary service	Support the transferring of up to 1024 same type services and independent tributaries, e.g. 10/100 Ethernet or TDM	Does not have tributary number for the same service
Multicast	Both service (or tributary) based Multicast and station-based Multicast between different nodes, e.g. 1024 10/100Mb/s Ethernets or MPEG2 channels can receive same broadcast services	Node-based Multicast between different nodes

	within a single node.	
PPPoE and PPPoA	Frame based transparent PPPoE and PPPoA transport from access to backbone along a MSR ring, in order to simplify accounting mechanism (e.g. Radius), reduce maintenance work, and improve latency variation (compared to Layer 2 and Layer 3 switch) in MAN.	Termination
Protection	Both service (or tributary) protection and aggregate-based protection within 50ms.	Aggregate based protection within 50ms
Topology	Ring of single-fiber, two-fiber (default use) and four-fiber. MSR also can be applicable to link, T type and Pseudo-mesh topologies by configuration.	Two- fiber ring
Link Address	Local link address	MAC address, worldwide use
VLAN and MAC Bridge	Uses directly back-to-back physical connection between two different MSR rings. The service channel is independent.	Support
Fairness algorithm.	It is not necessary. Carries can establish a set of connection relations of all Tributaries, determine	Support

	priority and allocate bandwidth among all nodes along MSR by using configuration function during project installation phase or on-line operation phase. Carries can also decide transport path of Tributary along either FWR or SWR.	
Different Rings connection	A low rate MSR span can be operated as a Tributary of a High Speed MSR, or back-to-back tributary connection.	Bridge or Line card connection
Circuit emulation	Support	Don't know
Tributary Based Protection, 1+1, 1:1, and 1:N	Support	Not support
Tributary Based Multicast	Support	Not support
Bandwidth Limitation of Tributary Based	Support	Not support
Tributary Bundle	Support	Not support
Line-Speed Filtering of Tributary Based	Support	Not support
Mirroring of Tributary	Support	Not support

Industrial applicability:

The present invention can provide the following capabilities:

(1). The protocol encapsulation and transport of Ethernet, Gigabit Ethernet, G.707 SDH circuit -- Transport of TU-11, TU-12 or TU-2, G.702 PDH circuit -- Synchronous and asynchronous circuit transport, Video signal, Voiceband signal, Digital channel supported by 64 kbit/s-based ISDN etc over a bi-directional symmetric counter-rotating two fibre optical rings (in the most case), a single fibre ring, a link-type and broadcast topology of fibres.

(2) Both service (or tributary) based protection and aggregate based protection within 50ms.

(3) Service (or tributary) based protection of 1+1, 1:1, and 1:N models.

(4) Both service (or tributary) based multicast and station-based multicast.

(5) Bandwidth limitation of service (or tributary) based.

(6) Tributary bundle with the same service type.

(7) Line-speed filtering of tributary based.

(8) Mirroring of tributary.

(9) Frame based transparent PPPoE and PPPoA transport from access to backbone along a MSR ring, in order to simplify accounting mechanism (e.g. Radius), reduce maintenance work, and improve latency variation (compared to Layer 2 and Layer 3 switch) in Metro Area Network.

Therefore, data node running LEP according to the present invention does not have the complexity of multiple layers of equipment and support systems. The simplicity of LEP used to MSR is achieved by integrating the functionality of multiple levels of system (e.g., router, data switch and transport system). This produces a new kind of data system that incorporates some of the functions of routers, bridges, data switches, and transport systems. This also provides a new economic model for deploying and supporting data services. Continued compatibility with all existing requirements and standards from ITU-T and other organizations is required. MSR-LEP is designated to achieve all of these.

LEP used to MSR according to the present invention is provided for default use on a bi-directional symmetric counter-rotating two fibre optical rings, and can also be changed to the use of single fibre ring, link-type and broadcast topology. Primary optical transport mechanism is defined to leverage the low cost Wide Area Interface Sublayer (WIS) of 10Gigabit Ethernet (IEEEP802.3ae) as an aggregate pipe. SDH/SONET physical transport is also supported. The service tributary interfaces used to LEP are defined to support Ethernet, TDM Circuit Emulation (including the emulation of G.707 SDH circuit -- Transport of TU-11, TU-12 or TU-2, G.702 PDH circuit -- Synchronous and asynchronous circuit transport, Video signal, Voiceband signal, Digital channel supported by 64 kbit/s-based ISDN) and/or an aggregate pipe of other MSR span with a lower rate than that of this aggregate pipe. LEP supports node based protection, tributary based 1+1, 1:1 and 1:N protection, tributary based multicast, tributary bandwidth Limitation, tributary bundle, tributary Line-Speed Filtering, tributary Mirroring, and is also defined to support forwarding of the MSR data link frame (also being a tributary) similar to functionality found in a more complex routing data system.

It is to be understood that other embodiments of the invention can be developed and fall within the spirit and scope of the invention and claims.

Claims:

1. A data transmission apparatus used in a multiple service ring including at least two nodes coupled to at least one aggregate pipe and at least one tributary, said apparatus comprising:

a TDM tributary RX framer coupled to a TDM tributary for deframing data frames received from said TDM tributary and extracting a destination node address, each of said data frames containing a plurality of channels in TDM manner;

a TDM identifier setting-up means for setting-up a TDM identifier indicating said data to be transmitted are TDM data; and

a TDM channel identifier setting-up means for setting-up a channel identifier indicating a specific TDM channel No. of the data to be transmitted; and

a TX framer for encapsulating the destination node address, the TDM identifier, the TDM channel identifier, and said TDM data to be transmitted into frames of the multiple service ring and transmitting the same along the aggregate pipe to a downstream neighbor node in the ring.

2. The data transmission apparatus according to claim 1, further comprising:

a RX framer for deframing data frames including a destination node address, at least one service type identifier, and actual data received from a aggregate pipe;

a service type determining means for determining the service type of received data based on said service type identifier, if the value of said service type identifier indicates that the received actual data are TDM data, determining the TDM channel No. from another TDM channel identifier preset at the transmitting node;

a TDM data extracting means for extracting the TDM data from the channel designated by said TDM channel No.; and

a TDM tributary TX framer for encapsulating said extracted TDM data into data frames to be transmitted to said TDM tributary.

3. The data transmission apparatus according to claim 2, further comprising:

an oscillator for generating a local clock signal;

a synchronizing means for synchronizing the timing of the local clock signal with that of all the nodes within the ring;

4. The data transmission apparatus according to claim 3, wherein said synchronizing means receives a timing signaling from another node in the ring or from at least an external timing source so as to align the timing with that node with an external timing source.

5. The data transmission apparatus according to claim 4, further comprising: a buffer for buffering the received TDM data if there is delay occurs until synchronization is achieved for the TDM data; in the event of buffer underflow, to maintain bit count integrity by inserting the appropriate number of dummy bits; in the event of buffer overflow, to maintain bit count integrity by dropping the appropriate number of bits.

6. The data transmission apparatus according to claim 5, further comprising: a counting means for tracking the sequence count values of the received TDM data frames, if there is duplicated frames, the duplicated frames are discarded; if there is lost frames, data link entity will send a MDL-ERROR-Indication to the layer management entity and/or appropriate number of dummy payloads are inserted for keeping the synchronization,

7. The data transmission apparatus according to claim 2, wherein said tributaries include at least one of Ethernet, Gigabit Ethernet, TDM Circuit Emulation including the emulation of G.707 SDH circuit -- Transport of TU-11, TU-12 or TU-2, G.702 PDH circuit -- Synchronous and asynchronous circuit transport, Video signal, Voiceband signal, Digital channel supported by 64 kbit/s-based ISDN, and an aggregate pipe of other MSR span with a lower rate than that of this aggregate pipe.

8. The data transmission apparatus according to claim 2, wherein said tributaries includes at least one mate standby tributary , and said apparatus comprises a tributary based protection unit for monitoring the link status of receiving the peer link frames and providing one of 1+1, 1:1, 1:N tributary based protection.

9. The data transmission apparatus according to claim 2, wherein said tributary based protection unit is for one of Ethernet and TCE.

10. The data transmission apparatus according to claim 2, wherein said TDM identifier is set at a TT field, and said apparatus further comprising: a tributary based multicasting unit for duplicating TDM data frames from a source tributary getting a payload of DL frame to other multiple tributaries with the same TT field value within a node.

11. The data transmission apparatus according to claim 2, further comprising: a bandwidth limitation unit for providing bandwidth limitation to a specific tributary.

12. The data transmission apparatus according to claim 2, wherein said TDM identifier is set at a TT field, and said apparatus further comprising: a bundle unit for bundling plural tributaries of the same TT field value to form a tributary bundle group(TBG) similar to one logical link.

13. The data transmission apparatus according to claim 2, further comprising: a line speed filtering unit for filtering and classifying frames based on certain protocol fields of upper layer in the payload of frame.

14. The data transmission apparatus according to claim 2, further comprising: a tributary mirroring unit for monitoring the incoming or outgoing traffic on a related tributary by connecting a sniffer to a "mirrored to" tributary.

15. The data transmission apparatus according to any one of claims 1-14, wherein said apparatus further comprising:

a first working ring input for receiving data frames including a destination node address, at least one service type identifier, and a first actual data, from a first upstream neighbor node, said service type identifiers including a field for the TDM identifier in case of TDM data frames;

a first RX filtering means for identifying whether said data are for the local node according to said destination address;

a first receiving service processing means for determining the service type destined for said data based on said service type identifier when said data are for the local node, said first receiving service processing means including said service type determining means;

a tributary Tx framing means for converting said data to a format of a service specified by said service type; and

at least one tributary output for outputting the converted data to a tributary service corresponding to said service type;

and

at least one tributary input for receiving data from at least one tributary service;

a first transmitting service processing means for setting-up a destination node address based on said destination node and setting-up a service type identifier based on the type of said input tributary service, said first transmitting service processing means including said TDM identifier setting-up means and said TDM channel identifier setting-up means;

a first working ring output for outputting said data frames to said first downstream neighbor node.

16. The apparatus according to claim 15, further comprising:

a second working ring input for receiving data frames including a destination node address, a service type identifier, and a second actual data, from a further upstream neighbor node;

a second working ring output for outputting said data frames to said second downstream neighbor node; and

a set of components which are duplicate to all the components involved for the first working ring input and the first working ring output.

17. The data transmission apparatus according to claim 16, wherein each of said data frames from the first working ring input and second working ring input is 4-octet based, and includes 32 bits of the destination node address NA, next 32 bit definition field including TTL(time to live) indicator, multicast type indicator U/M/B, a first working ring or second working ring indicator FWR/SWR, priority indicator, the reserved field, the service type identifier as TT(tributary type) and TN(tributary No.), control signalling network management identifier(CS&NM) data and frame sequence

number(FSN), N(integer)*32bits of payload or parameters of CS & NM packets as said actual data, and 32 bits of FCS field.

18..The data transmission apparatus according to claim 17, wherein when the service type is found to be TDM service, the TT field is set to a predetermined range of values as the TDM identifier; and one of the other existing fields is set to the TDM channel No. as the TDM channel identifier.

19. The data transmission apparatus according to claim 18, wherein the FSN field is set as the TDM channel identifier, and the count value applied to FSN field starts with 0, is incremented sequentially to 31 or 255 and is numbered modulo 32 or 256 frames must be delivered in order, the Data Link entity in the receive side must detect the lost or duplicated frames, and track the following status of dynamic data stream, to reflect Frame sequence number and count, Frame loss (if occur) and Frame duplication (if occur), reorder and sort into the correct order otherwise drop those disorder frames and report to the layer management entity by MDL-ERROR-Indication.

20. The data transmission apparatus according to claim 18, wherein when the TT field is set to lower than 100, it indicates a TDM tributary service; and the CS & NM field is set to the TDM channel No. as the TDM channel identifier, and the value of the TDM channel No. in the CS&NM field is 0-31.

21. The data transmission apparatus according to claim 19, a low rate MSR span is operated as a Tributary of a High Speed MSR, or back-to-back tributary connection.

22. The data transmission apparatus according to claim 20, frame based PPPoE and PPPoA transport are transparently running from access to backbone along a MSR ring, in order to simplify accounting mechanism (e.g. Radius), reduce maintenance work, and improve latency variation (compared to Layer 2 and Layer 3 switch) in MAN.

23. A resilient multiple service ring system comprising a plurality of nodes, each node including a data transmission apparatus according to any one of claims 1-18, wherein each of said nodes is assigned a node address(NA), and data incoming to a node contains a destination node address, and said destination node address is XOR'ed with the NA of the local node to check for match or mismatch.

24. The system according to claim 23, wherein an external timing source is provided to one of the nodes in the ring, and the other nodes make reference to the timing signaling from said one node for synchronization.

25. The system according to claim 24, wherein said nodes are coupled in a double fibre ring or a single fibre ring.

26. The system according to claim 24, wherein one of the nodes is only coupled to another node with a tributary.

27. The system according to claim 24, wherein one of the nodes forms broadcasting connection to other nodes with aggregate pipes in a DVB application.

28. The system according to claim 24, wherein one of the nodes is only coupled to each of the other nodes with a tributary to form a pseudo-mesh connection while other four nodes are connected to form a two-fibre ring.

29. A data transmission method used in a multiple service ring including at least two nodes coupled to at least one aggregate pipe and at least one tributary, comprising the steps of:

deframing data frames received from a TDM tributary and extracting a destination node address, each of said data frames containing a plurality of channels in TDM manner;

setting-up a TDM identifier indicating said data to be transmitted are TDM data;

setting-up a channel identifier indicating a specific TDM channel No. of the data to be transmitted; and

encapsulating the destination node address, the TDM identifier, the TDM channel identifier, and said TDM data to be transmitted into frames of the multiple service ring and transmitting the same along the aggregate pipe to a downstream neighbor node in the ring.

30. The method according to claim 29, further comprising the steps of:

deframing data frames including a destination node address, at least one service type identifier, and actual data received from a aggregate pipe;

determining the service type of received data based on said service type identifier, if the value of said service type identifier indicates that the received actual data are

TDM data, determining the TDM channel No. from another TDM channel identifier preset at the transmitting node;

extracting the TDM data from the channel designated by said TDM channel No.; and encapsulating said extracted TDM data into data frames to be transmitted to said TDM tributary.

31. The method according to claim 30, further comprising the steps of:

generating a local clock signal;

synchronizing the timing of the local clock signal with that of all the nodes within the ring.

32. The method according to claim 31, wherein a timing signaling is received from another node in the ring or from an external timing source so as to align the timing with other nodes.

33. The data transmission apparatus according to claim 32, further comprising: buffering the received TDM data if there is delay occurs until synchronization is achieved for the TDM data; in the event of buffer underflow, to maintain bit count integrity by inserting the appropriate number of dummy bits; in the event of buffer overflow, to maintain bit count integrity by dropping the appropriate number of bits.

34. The method according to claim 33, further comprising: counting and tracking the sequence count values of the received TDM data frames, if there is duplicated frames, the duplicated frames are discarded; if there is lost frames, appropriate number of dummy payloads are inserted for keeping the synchronization.

35. The method according to claim 34, wherein said tributaries include at least one of Ethernet, Gigabit Ethernet, TDM Circuit Emulation including the emulation of G.707 SDH circuit -- Transport of TU-11, TU-12 or TU-2, G.702 PDH circuit -- Synchronous and asynchronous circuit transport, Video signal, Voiceband signal, Digital channel supported by 64 kbit/s-based ISDN, and an aggregate pipe of other MSR span with a lower rate than that of this aggregate pipe.

36. The method according to any one of claims 29-35, wherein each of said data frames from the first working ring input and second working ring input is 4-octet

based, and includes 32 bits of the destination node address NA, next 32 bit definition field including TTL(time to live) indicator, multicast type indicator U/M/B, a first working ring or second working ring indicator FWR/SWR, priority indicator, the reserved field, the service type identifier as TT(tributary type) and TN(tributary No.), control signalling network management identifier(CS&NM) data and frame sequence number(FSN), N(integer)*32bits of payload or parameters of CS & NM packets as said actual data, and 32 bits of FCS field.

37. The method according to claim 36, wherein when the service type is found to be TDM service, the TT field is set to a predetermined range of values as the TDM identifier; and one of the other existing fields is set to the TDM channel No. as the TDM channel identifier.

38. The data transmission apparatus according to claim 37, the FSN field is set as the TDM channel identifier,and the count value applied to FSN field starts with 0, is incremented sequentially to 31 or 255 and is numbered modulo 32 or 256 frames must be delivered in order, The Data Link entity in the receive side must detect the lost or duplicated frames, and track the following status of dynamic data stream, to reflect Frame sequence number and count, Frame loss (if occur) and Frame duplication (if occur), reorder and sort into the correct order otherwise drop those disorder frames and report to the layer management entity by MDL-ERROR-Indication.

39. The data transmission apparatus according to claim 37, wherein when the TT field is set to lower than 100, it indicates a TDM tributary service; and the CS & NM field is set to the TDM channel No. as the TDM channel identifier, and the value of the TDM channel No. in the CS&NM field is 0-31.

Abstract

This application presents Link Encapsulation Method (LEP) Used to Multiple Services Ring (MSR). LEP used to MSR is provided for default use on a bi-directional symmetric counter-rotating two fibre optical rings, and can also be changed to the use of single fibre ring, link-type and broadcast topology. Primary optical transport mechanism is defined to leverage the low cost Wide Area Interface Sublayer (WIS) of 10Gigabit Ethernet (IEEEP802.3ae) as an aggregate pipe. SDH/SONET physical transport is also supported. The service tributary interfaces used to LEP are defined to support Ethernet, TDM Circuit Emulation (including the emulation of G.707 SDH circuit -- Transport of TU-11, TU-12 or TU-2, G.702 PDH circuit -- Synchronous and asynchronous circuit transport, Video signal, Voiceband signal, Digital channel supported by 64 kbit/s-based ISDN) and/or an aggregate pipe of other MSR span with a lower rate than that of this aggregate pipe. LEP supports node based protection, tributary based 1+1, 1:1 and 1:N protection, tributary based multicast, tributary bandwidth Limitation, tributary bundle, tributary Line-Speed Filtering, tributary Mirroring, and is also defined to support forwarding of the MSR data link frame (also being a tributary) similar to functionality found in a more complex routing data system.

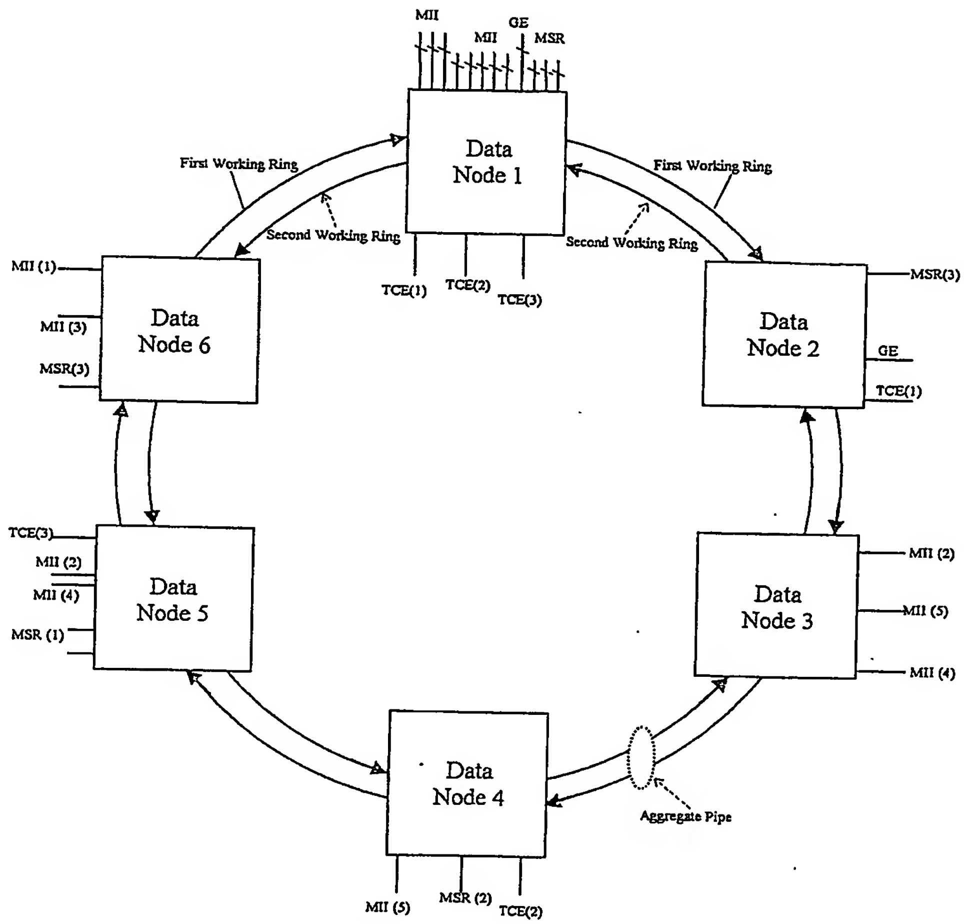

FIG. 1

The Topology of Multiple Services Ring

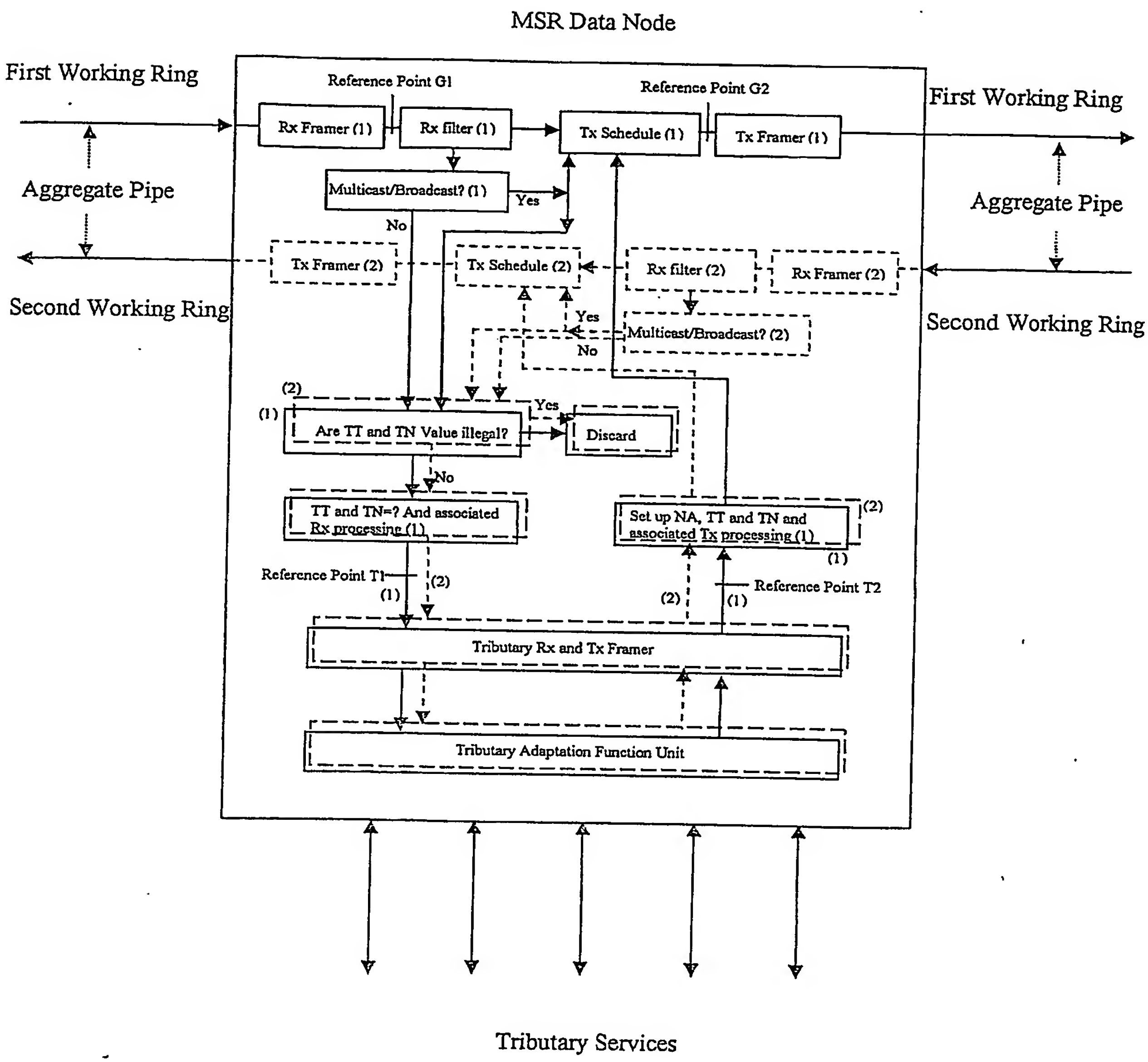

FIG. 2

Tx and Rx Function Diagram of MSR Data Node

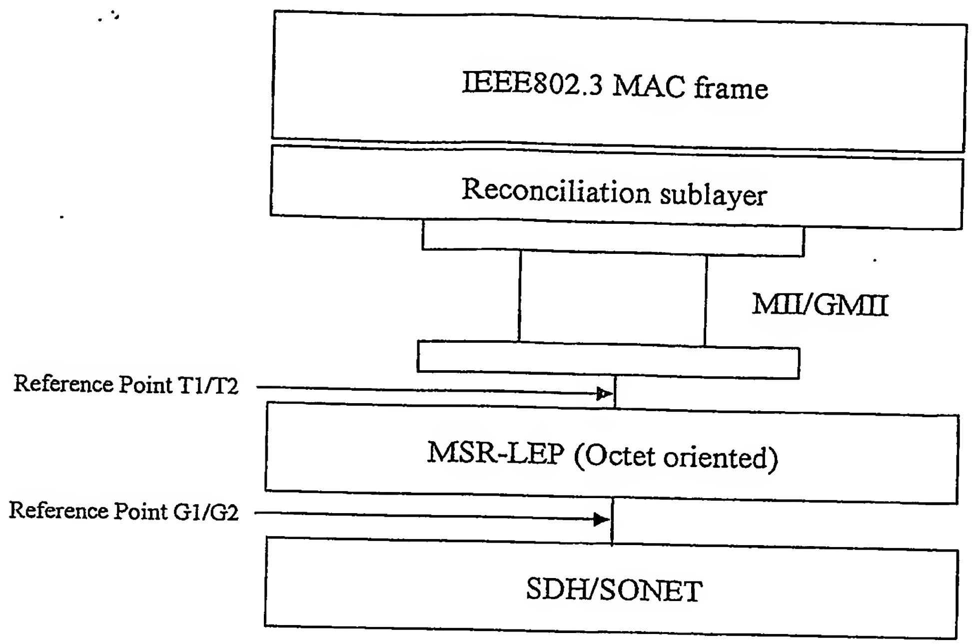

Fig. 3

Protocol Stack of Ethernet over SDH/SONET using MSR-LEP in SDH/SONET based Aggregate Pipe

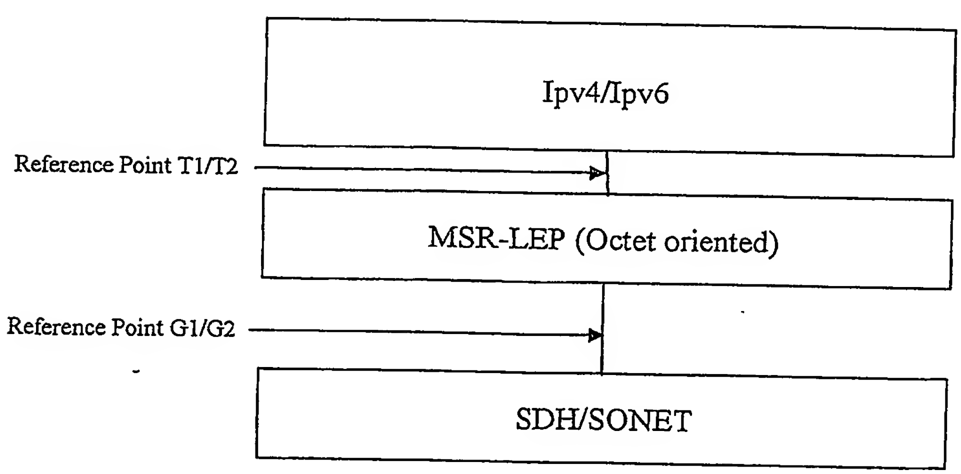

Fig. 4

Protocol Stack of IP over SDH/SONET using MSR-LEP in SDH/SONET based Aggregate Pipe, it will be used to network management, control signalling and Layer 3 forwarding packet

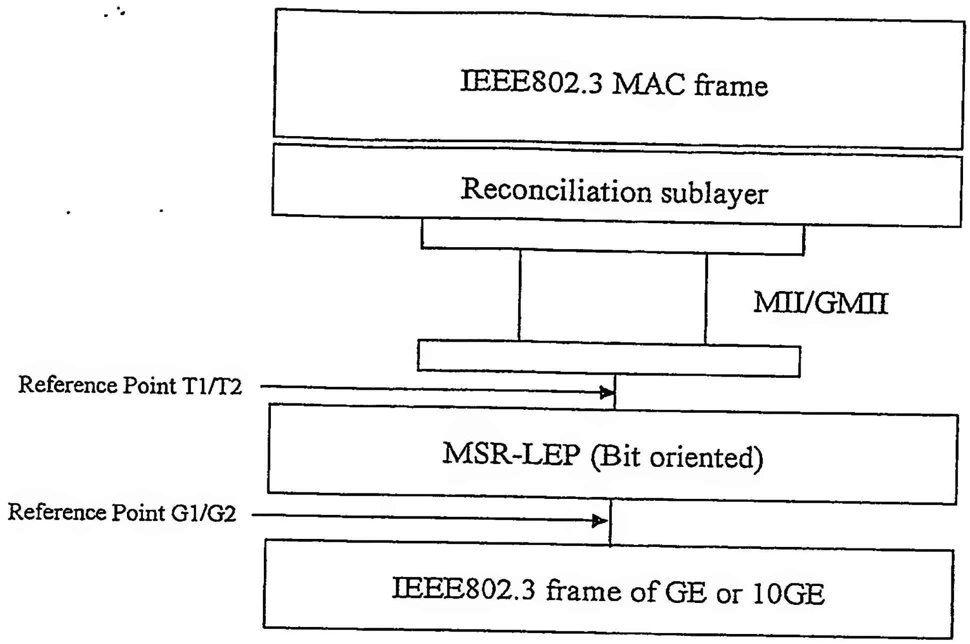

Fig. 5

Protocol Stack of Ethernet over GE or 10GE in GE or 10GE based Aggregate Pipe

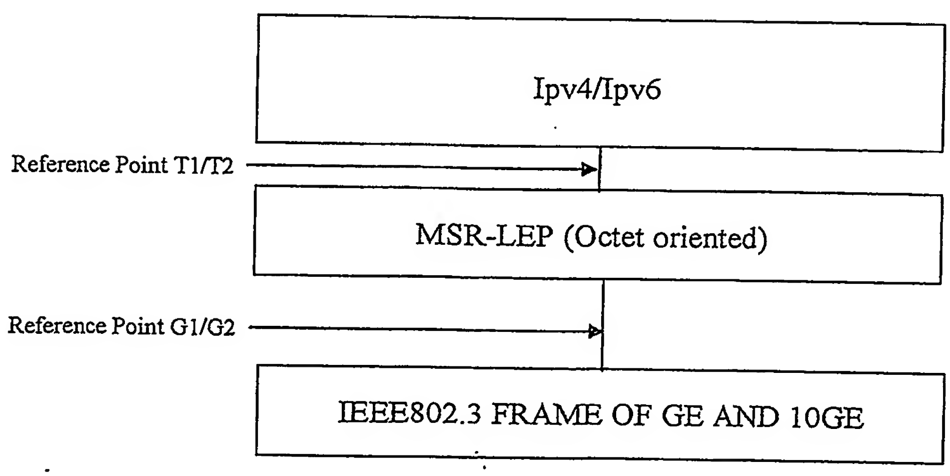

Fig. 6

Protocol Stack of IP over Ethernet in GE and 10GE based Aggregate Pipe, it will be used to network management, control signalling and Layer 3 forwarding packet

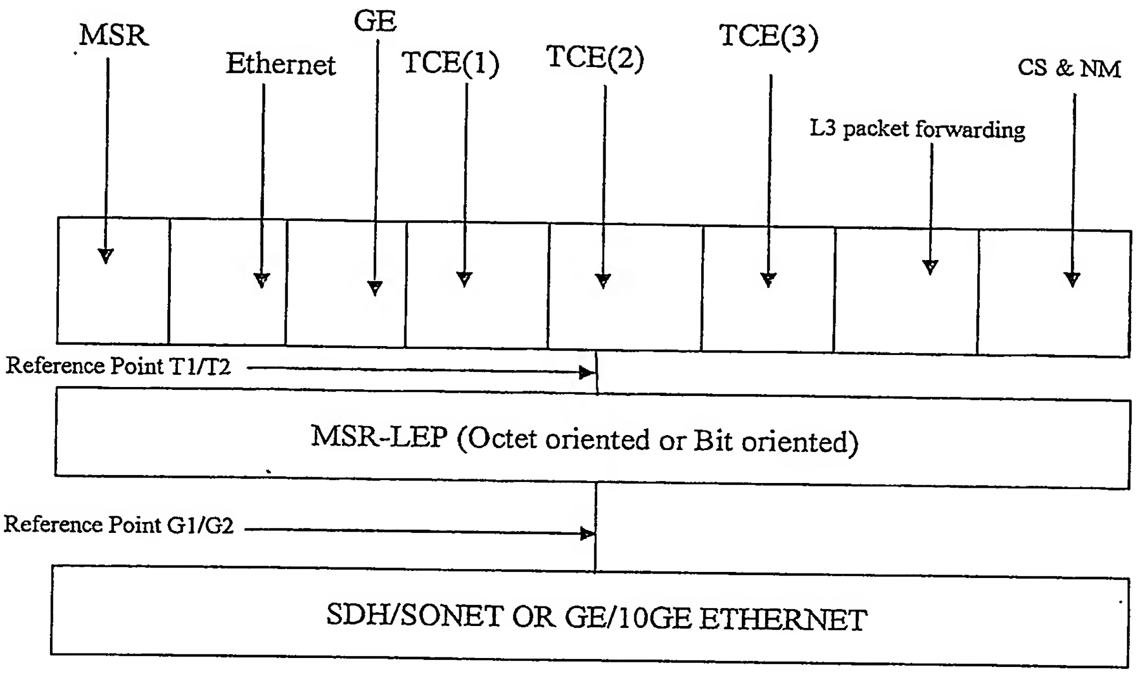

Fig. 7

Generic Protocol Stack of MSR

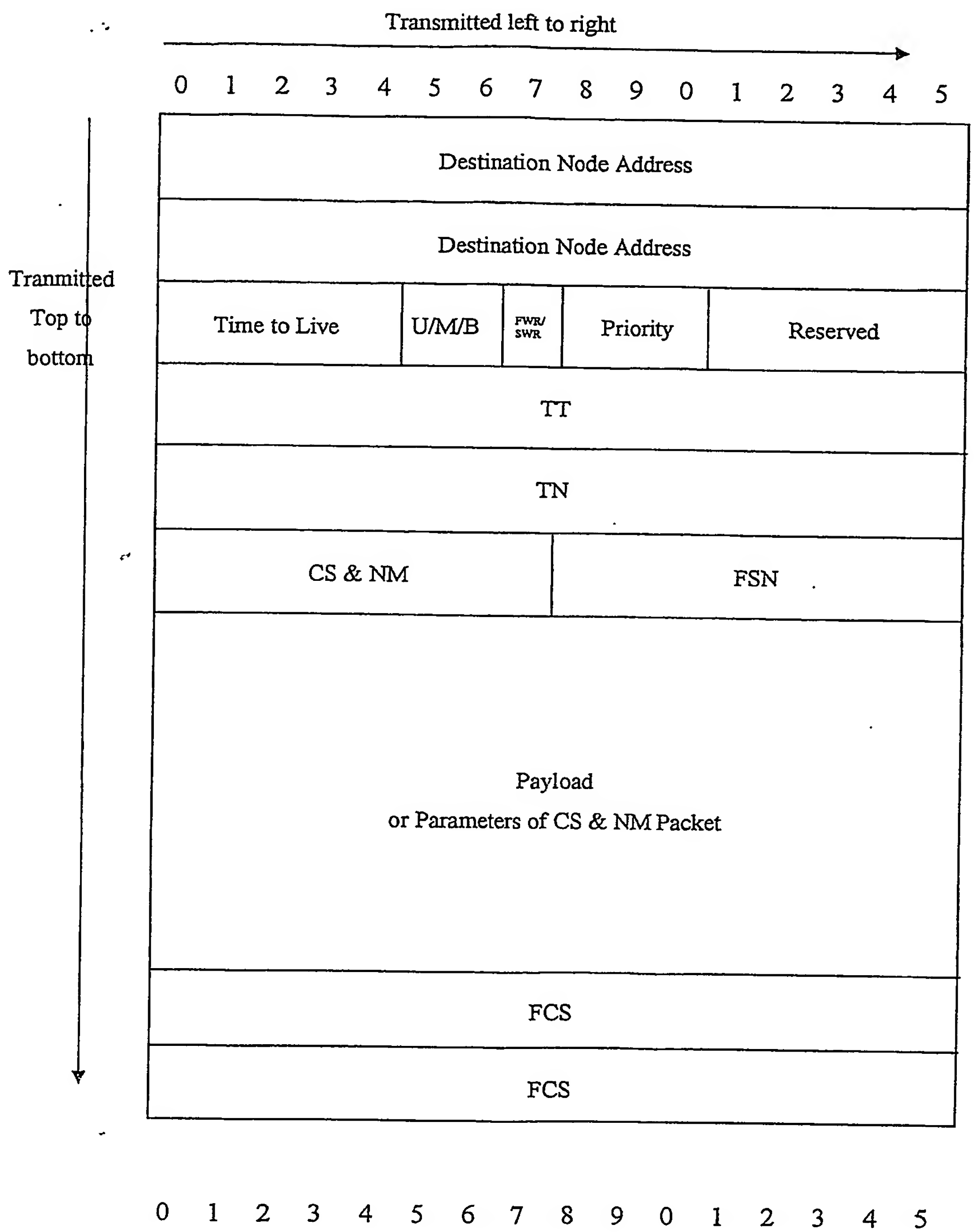

Fig. 8

Generic Frame Format of MSR

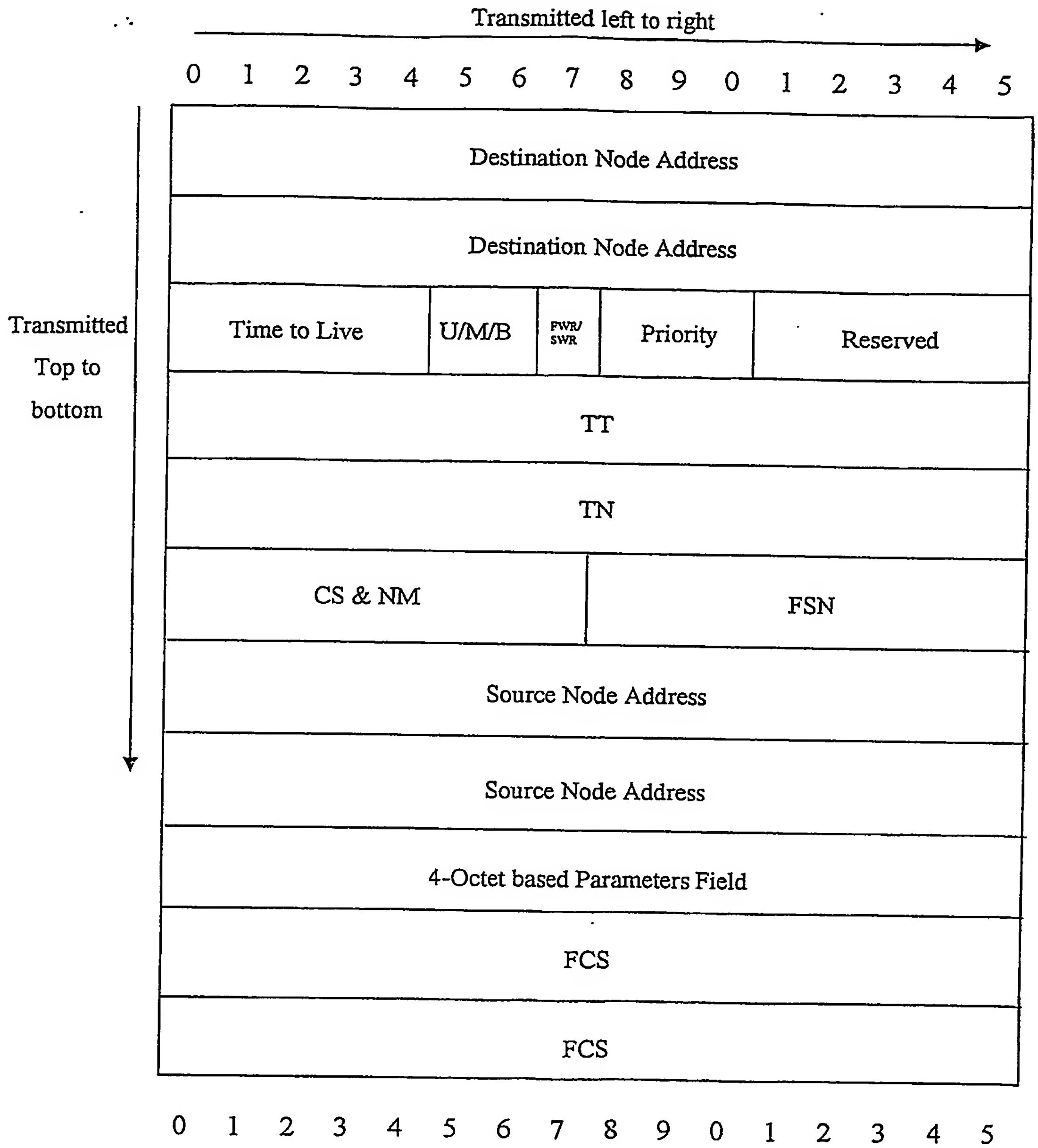

Fig. 9

Generic Format of CS & NM Frames

TCCR ID =TSNi ID +

0 1	2 3 4 5 6 7
U/M/B	Length

+TSNj ID +TSNk ID+TSNm ID ……

Multicast/Broadcast Mode

TCCR ID =TSNi ID +

0 1	2 3 4 5 6 7
01	Length

+TSNj ID

Unicast Mode

TSNi ID=NA+TT+TSN

Fig. 10

Expressions of TN ID and TCCR ID

PCT/CN 02/ 0 0 5 0

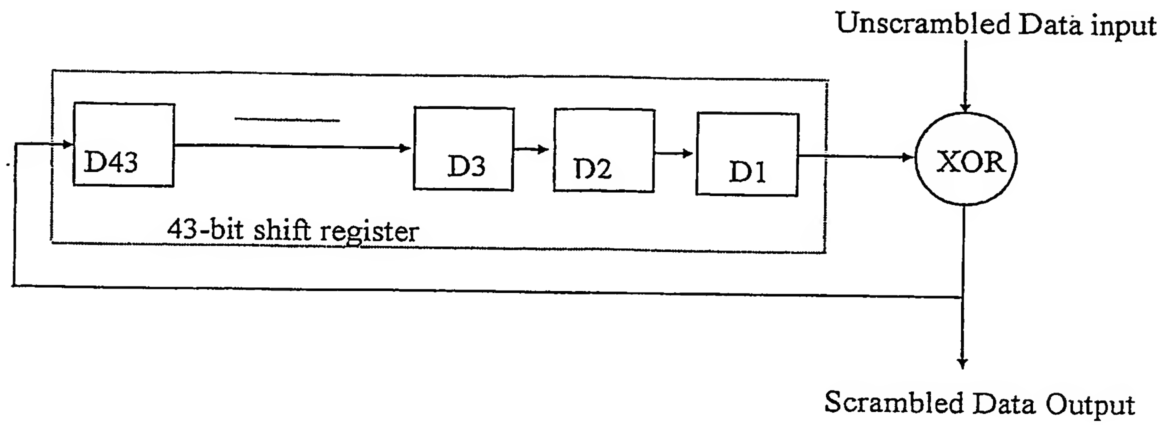

FIG. 11A
Transmitter diagram

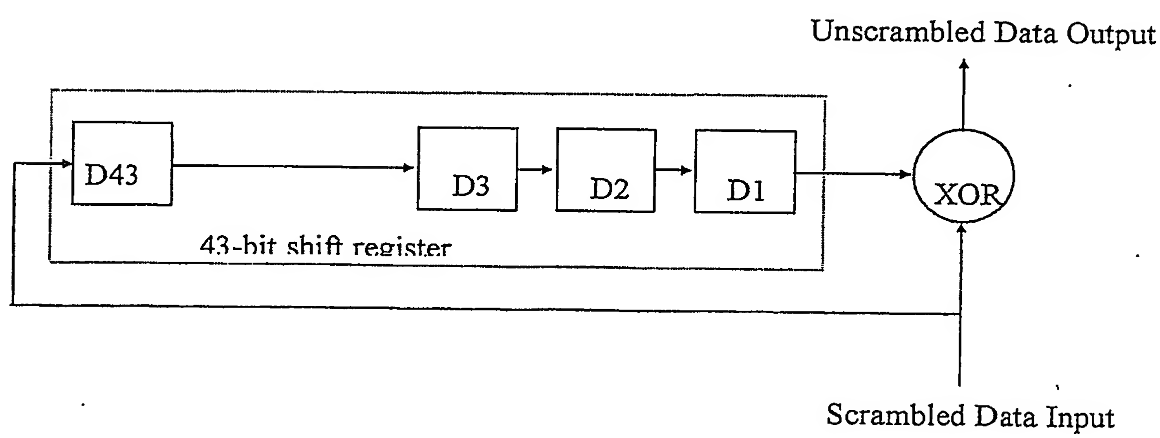

FIG. 11B
Receiver diagram

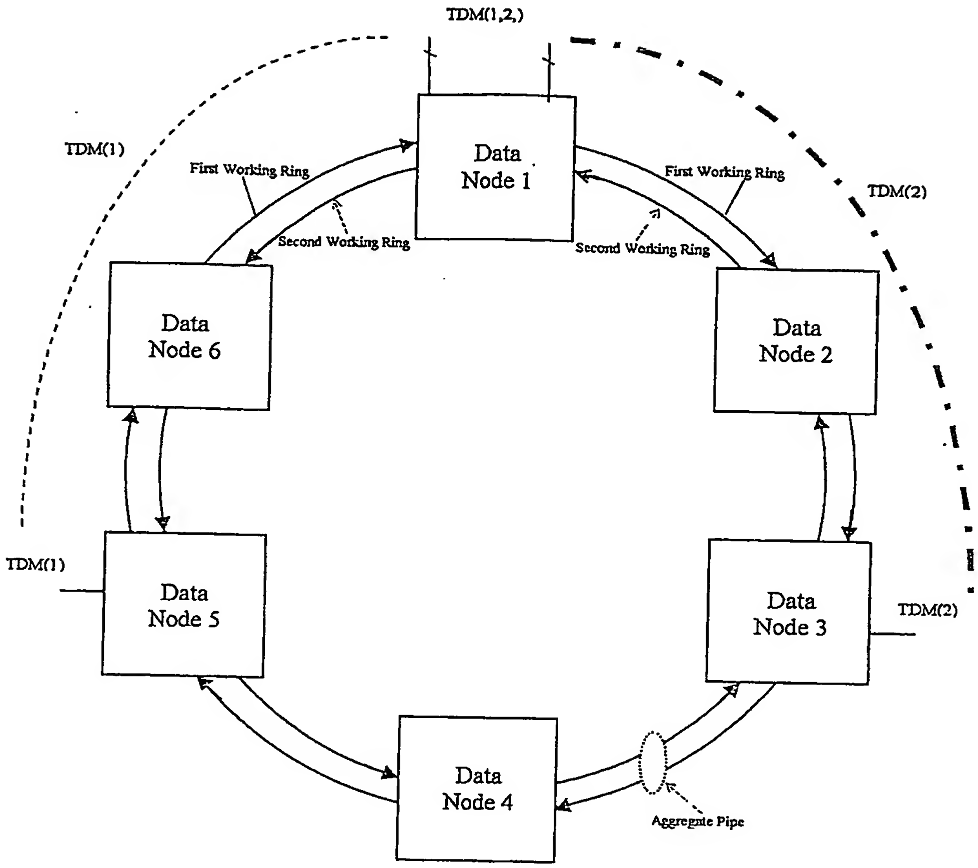

FIG. 12

The TDM Service Channel along MSR

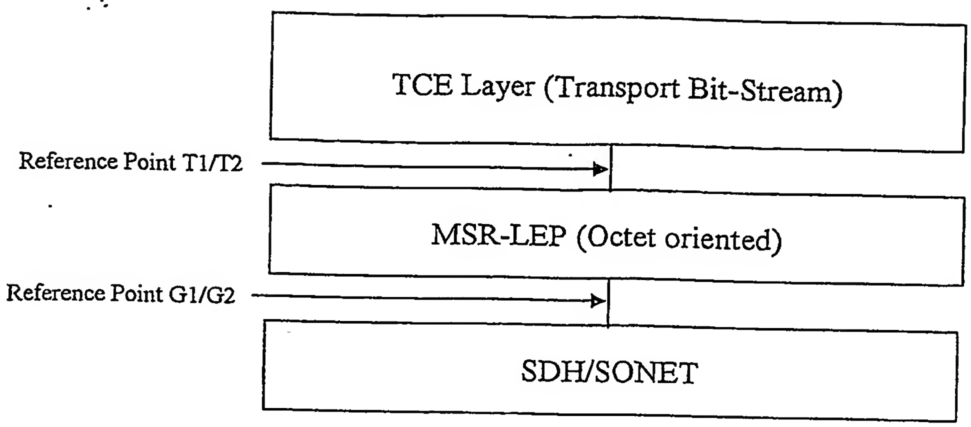

FIG. 13

TDM SERVICE CHANNEL OVER OCTET ORIENTED MSR-LEP

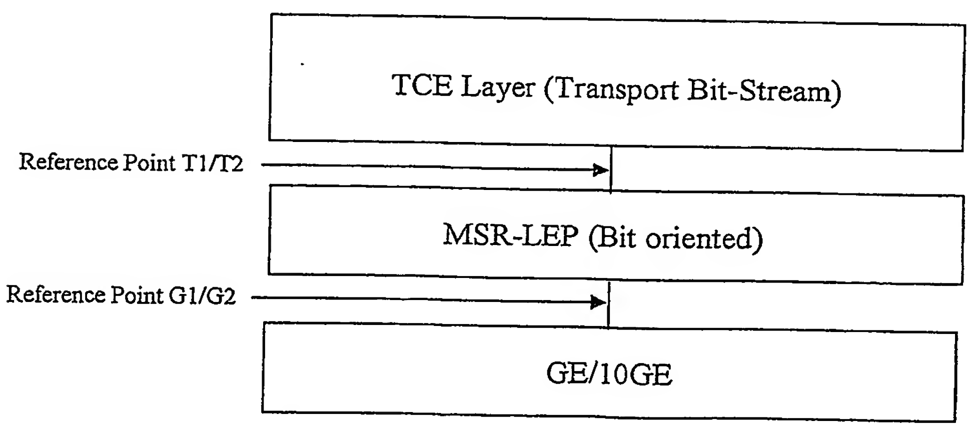

FIG. 14

THE TDM SERVICE CHANNEL OVER BIT ORIENTED MSR-LEP

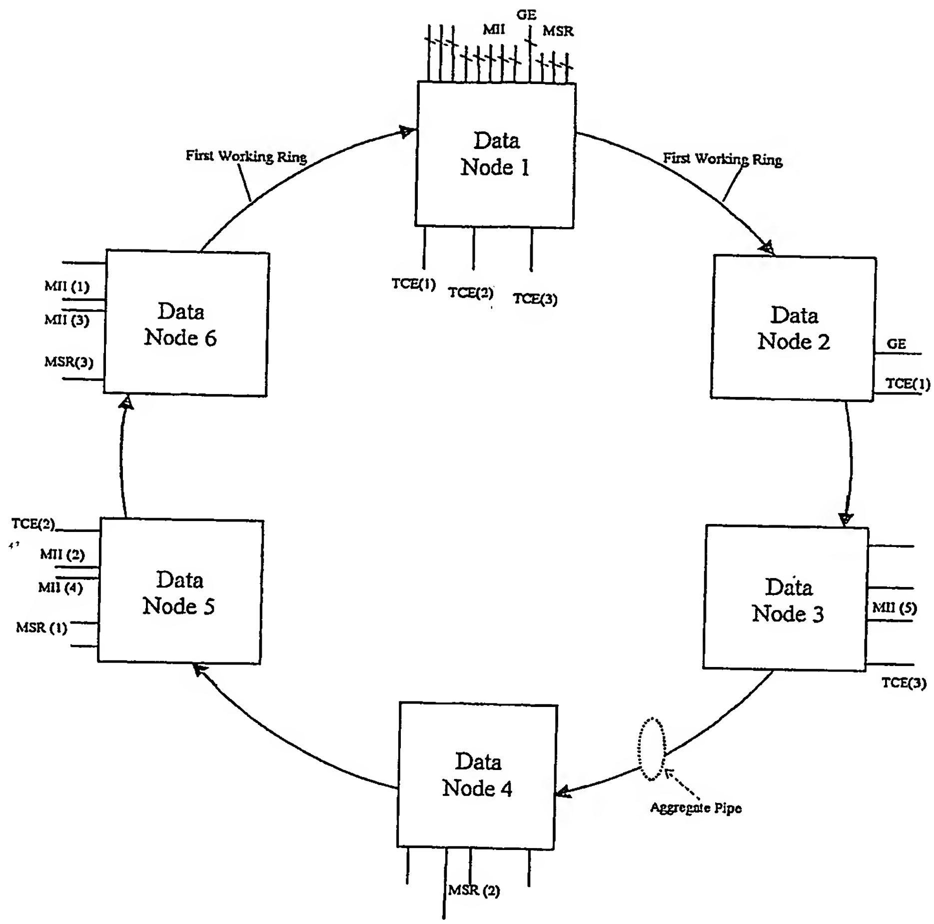

FIG. 15

The Single Fibre Ring of MSR

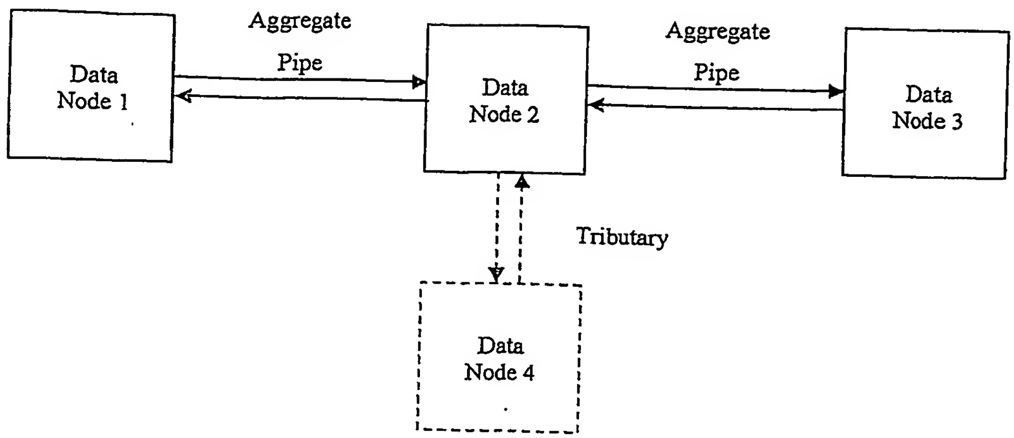

FIG. 16

A MSR Topology, Link-type with Adding and Dropping Tributary Services

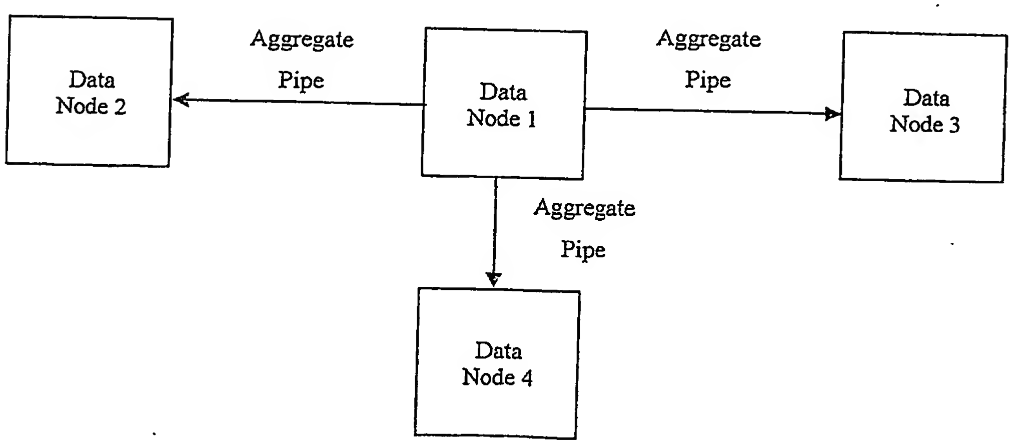

FIG. 17

A MSR Topology, Broadcast Connection to DVB Application

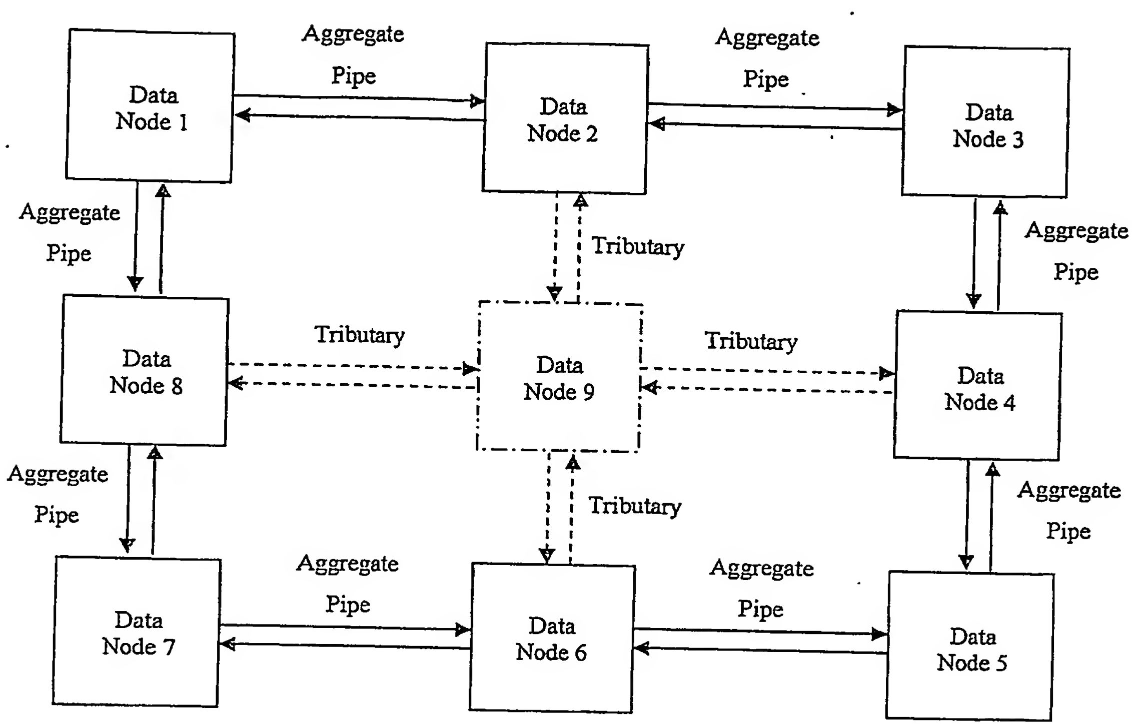

FIG. 18

A MSR Topology, Pseudo-mesh Connection

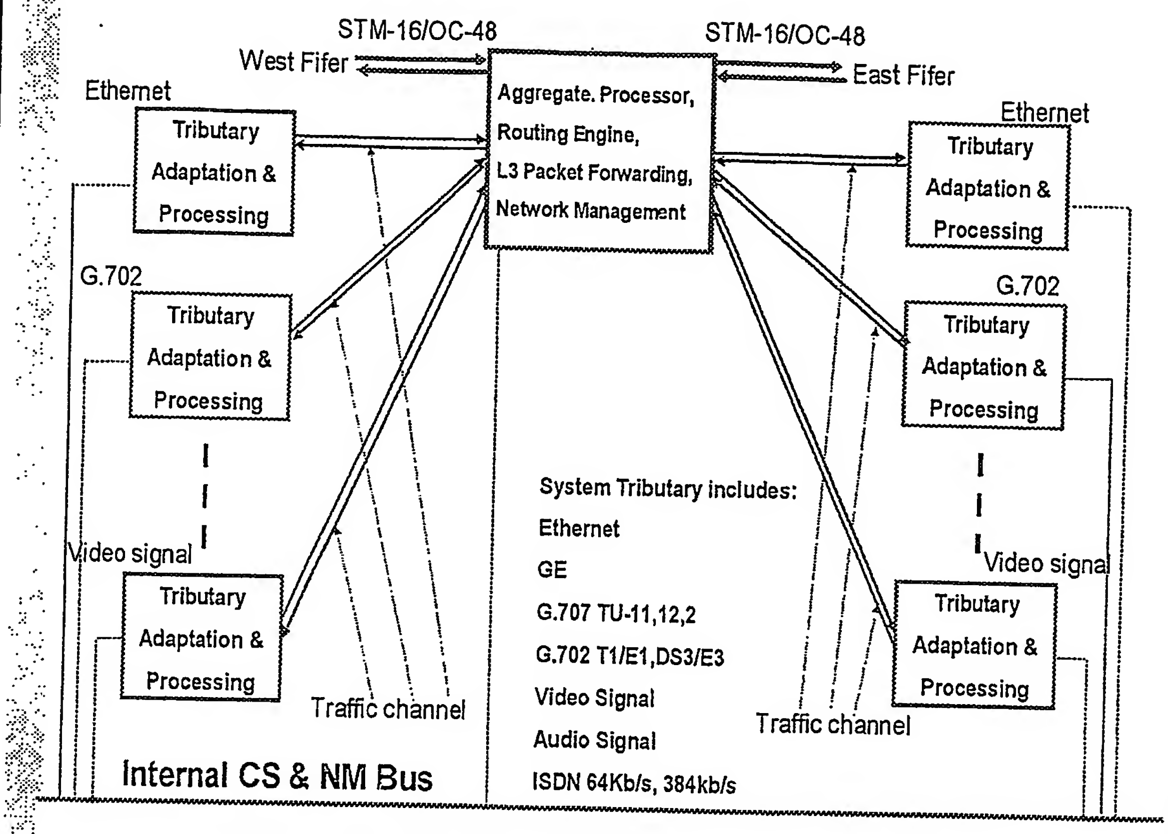

Fig. 19 – Hardware Architecture example of MSR

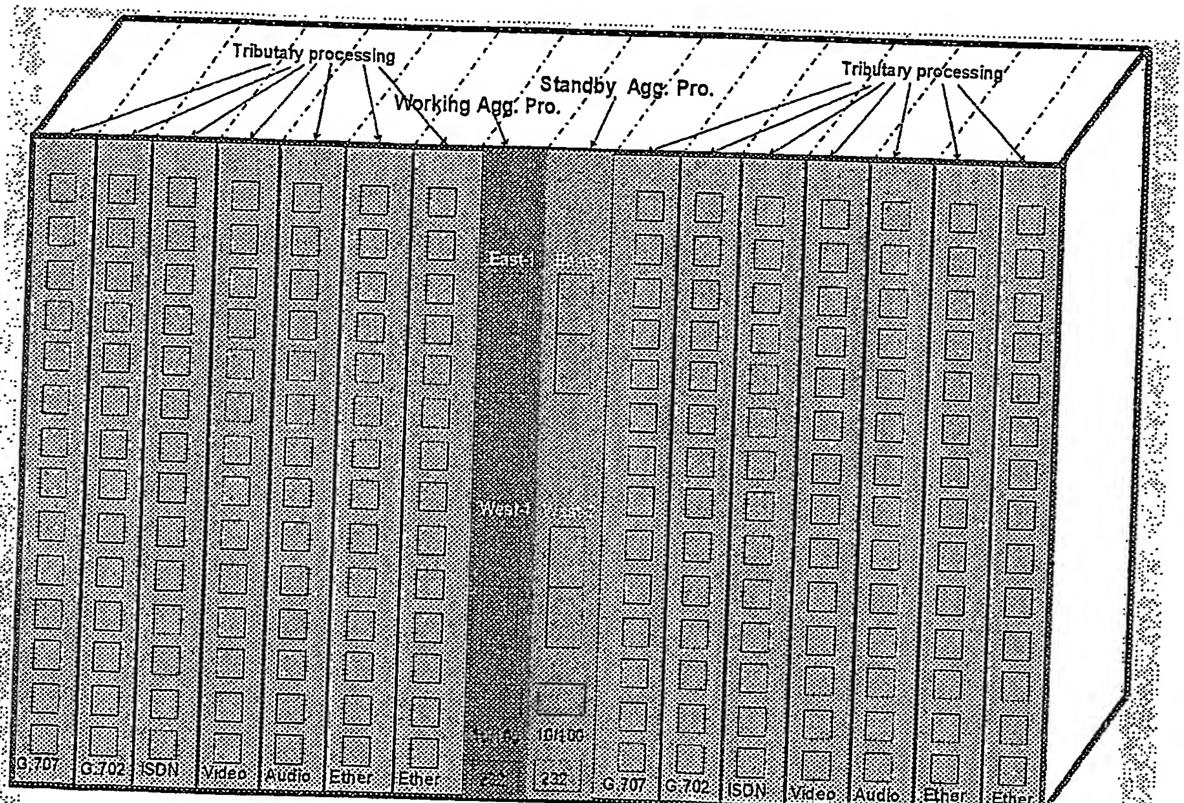

Fig . 20 – Layout of MSR Shelf

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